PUBLIC HEALTH REPORTS

In this issue

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

PUBLIC HEALTH REPORTS

Volume 74 Number 2

FEBRUARY 1959

Published since 1878

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frontispiece

As a step in the bentonite flocculation test for trichinosis, trichina larvae are macerated into a suspension in a Ten Broeck tissue grinder. The extract is then absorbed on bentonite particles to make a stable antigen (see paper on trichinosis, p. 159).

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Public Health Reports, published since 1878 under authority of an act of Congress of April 29 of that year, is issued monthly by the Public Health Service pursuant to the following authority of law: United States Code, title 42, sections 241, 245, 247; title 44, section 220. Use of funds for printing this publication approved by the Director of the Bureau of the Budget, August 24, 1957.

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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PUBLIC HEALTH SERVICE
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Poliomyelitis Vaccination

SURGEON GENERAL LEROY E. BURNEY

IN 1958 there was more paralytic poliomyelitis in the United States than in 1957. The rates for paralytic cases were highest in 1-year-olds, and more than half of all paralytic cases occurred in children under 5 years of age.

Despite the high susceptibility of the Nation's preschool children, about a third have had no poliomyelitis vaccine. The total unvaccinated population under 40 years of age, including children and young adults, is more than 40 million.

These salient facts about the progress of vaccination against poliomyelitis were the subjects of a daylong discussion in Washington, D. C., in early December 1958. The meeting was called by the Public Health Service and was attended by representative State and city health officers and health educators and officials of the American Medical Association, the American Academy of Pediatrics, the Association of State and Territorial Health Officers, the National Conference of State Health Educators, the National Health Council, the National Foundation, the Advertising Council, Inc., and the Pharmaceutical Manufacturers Association.

The group agreed that the story of the Salk vaccine during the past 3 years is a truly remarkable one. More than 50 million persons have been vaccinated, and the incidence of poliomyelitis has dropped gratifyingly. Seldom, if ever, in the history of public health have so many persons taken advantage so quickly of a major preventive health measure. Seldom has there been a greater mobilization of health and medical resources, or a more intensive and sustained effort by official and voluntary organizations to accomplish a health purpose.

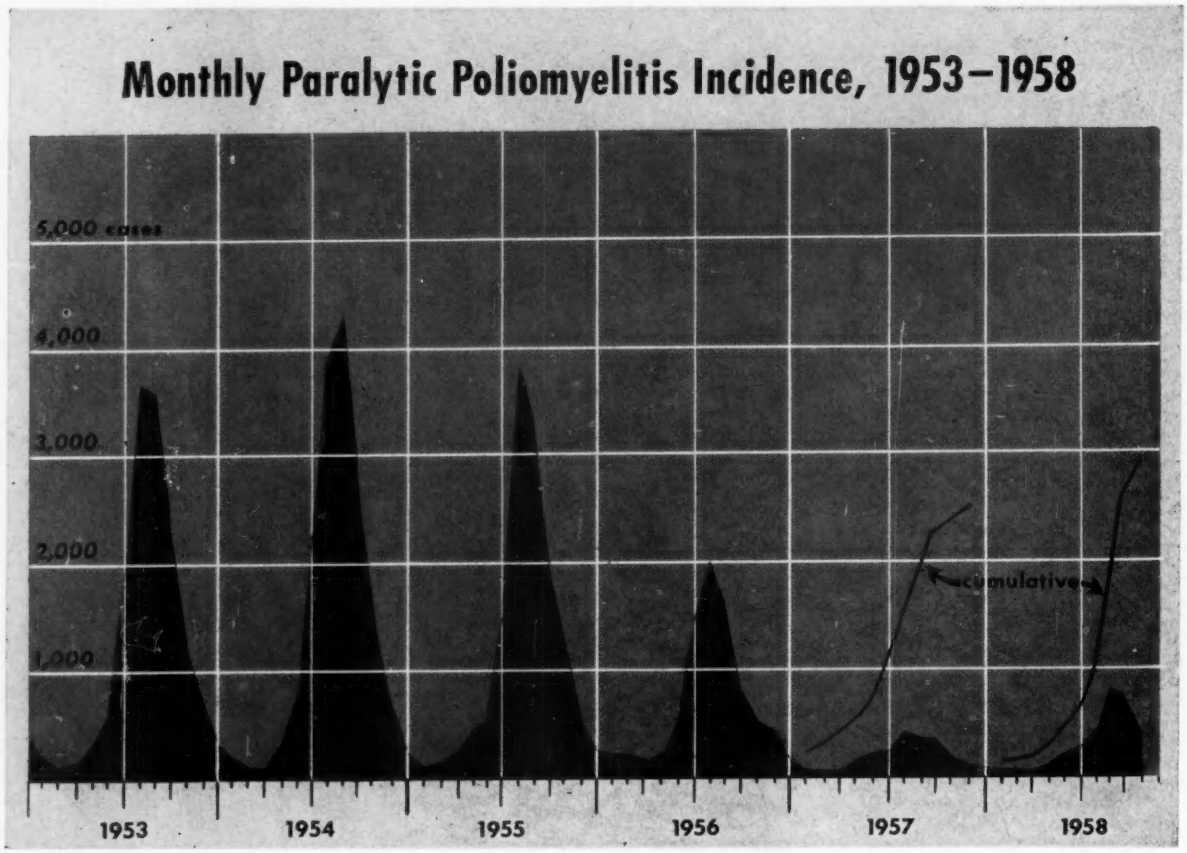
We have at hand a highly effective vaccine. The 1958 poliomyelitis experience, to be described in the Communicable Disease Center's 1958 Poliomyelitis Surveillance Report, has provided additional evidence to support this statement.

Yet the task remains to carry further the work of immunization. Although the Salk vaccine is not a 100 percent preventive and although the available data suggest that poliovirus continues to circulate even in well-vaccinated communities, it is evident that much of the paralytic poliomyelitis that occurred in 1958 could have been prevented if more persons had been vaccinated. It is equally clear that, by pushing forward with vaccination programs now, much can be done to reduce the number of paralytic cases that will otherwise occur in 1959 and subsequent years.

To translate what we know about a problem into effective action to solve it is, of course, one of the principal and never-ending challenges of society. Every health administrator is aware of the twin needs: to dispel ignorance and to overcome apathy.

Why have vaccinations lagged in the past 6 months? What means can be used to stimulate more people to seek vaccinations? These two questions were the chief subjects discussed at the Washington meeting.

The participants agreed that the primary responsibility for reaching the unvaccinated remains, as it always has, with the local community. Much has been done that can contribute to the accomplishment of the remaining task. The public is now widely informed about the vaccine, and professional people have gained valuable experience. These advantages, however, only partially offset the fact that the



people who now remain unvaccinated are largely those who are difficult to reach with any health program. To get them vaccinated will require "face to face" campaigns under the leadership of local groups.

Surveys have demonstrated that many of the unvaccinated are in the lower socioeconomic groups. Reports from three of the 1958 epidemic areas stress this point. It is borne out, as well, by a sample survey conducted in Atlanta by the Public Health Service's Communicable Disease Center. It would be a mistake, however, to attribute the lag solely to economic reasons. Many communities, through local medical societies or public agencies, have offered vaccine free or at minimal cost during these past 3 years and found too few takers. Such factors as educational status, accessibility of clinics, simple fear of the needle, the human fault of procrastination, and, of course, indifference and apathy—all have a bearing. These and other problems are discussed in a paper by Rosenstock, Derryberry, and Carriger in this issue of *Public Health Reports*, pp. 98–103.

Undoubtedly the relative importance of the factors that interfere with acceptance of poliomyelitis vaccination varies from community to community. It is therefore important for each community to determine for itself what its chief problems are and how they relate to the current vaccination status in the various geographic sections of the city, such as census tracts or school districts. The resulting information then needs to be used to tailor the community's vaccination program to fit the local situation.

Professional health workers need not be reminded of how the process of acquiring this information can be used to enlist the active participation of physicians, agencies, and organizations in the vaccination program. It has been demonstrated many times that such groups work much more effectively throughout a program if they are consulted and utilized in the factfinding stage. By this device they are made to feel keenly their responsibility to do something about the findings that their studies reveal.

At the Washington meeting, the Public

Health Service announced that it was willing to help in this aspect of local community drives by lending to communities some of the technicians who carried out the Atlanta survey. I am glad to repeat that offer here.

The emphasis on local community responsibility is also explicitly set forth in recommendations unanimously adopted by the House of Delegates of the American Medical Association at the annual meeting on December 4, 1958. A happy coincidence of dates enabled us to provide the representatives at our meeting with a copy of the AMA resolution.

In brief, the recommendations are that (*a*) each physician assume responsibility for making sure that all members of the families he sees are fully vaccinated; (*b*) that State medical societies work with State health departments to bring county medical societies together with health departments to work out vaccination programs; and (*c*) that county medical societies meet with local health departments to survey local problems and devise ways to meet local situations.

In discussing the role of the local community with respect to poliomyelitis vaccination activities, I do not mean to suggest that the Public Health Service will not continue its efforts. We shall, of course, continue our surveillance and reference diagnostic services and continue to offer assistance when epidemics threaten. In promoting vaccinations, we shall continue to conduct a program of public information and education through the States and in cooperation with national organizations.

We have asked again and have been assured of the assistance of the Advertising Council in a national campaign, to begin in the spring, of newspaper, radio, and television reminders of the importance of poliomyelitis vaccinations.

All the national organizations represented at our meeting have indicated that they will continue their national programs and will urge their State and local affiliates to do all within their power to make community drives a success. The National Health Council has also offered its assistance in working with other national organizations.

The new element introduced at the Washington meeting, in other words, was not a shift in the relative responsibility assumed by national, State, and local organizations but rather a shift in the way these efforts would be channeled. Until now, programs have been aimed principally at the general public. It is proposed now that in addition we seek to pinpoint our targets, finding as precisely as possible what segments of the population in each community have not been reached, and devising programs to meet their special needs.

Zero Tolerance for Aramite Established

The Food and Drug Administration has ruled that no residue of the pesticide Aramite is permissible on fruit and vegetables in interstate commerce. The new order, effective December 24, 1958, rescinds the previously established tolerance of 1 ppm.

The action was based on data from animal feeding studies, submitted by the manufacturer, which show that Aramite when fed at levels as low as 500 ppm causes cancer in dogs.

At the request of the manufacturer, and as provided by law, an advisory committee of scientists was nominated by the National Academy of Sciences and appointed by the Food and Drug Administration to consider the data from the feeding studies. The committee recommended the zero tolerance for Aramite.

Analysis of research on the social and psychological factors which influence people to accept or reject poliomyelitis vaccination suggests that people who are currently incompletely vaccinated can best be reached through personal, face-to-face contacts.

Why People Fail to Seek Poliomyelitis Vaccination

IRWIN M. ROSENSTOCK, Ph.D., MAYHEW DERRYBERRY, Ph.D., and BARBARA K. CARRIGER, B.A.

EPIDEMIOLOGICAL investigations of the 1958 outbreaks of poliomyelitis add to the growing body of evidence that Salk vaccine is safe and effective in preventing the disease. The major proportion of cases, particularly the paralytic, are occurring among incompletely vaccinated individuals. Thus the prevention of such epidemics as occurred in 1958 will not devolve primarily upon technical development of preventives. Rather, prevention will require increasing the number of people who protect themselves and their families through vaccination. Public health workers desiring to bring about such action can be more effective if they know why people fail to accept poliomyelitis vaccination, their motivations in rejecting or accepting it, the conditions under which they will respond to appeals for action, and the communication channels through which they get health information.

To provide such information quickly, the Public Health Service, through the regional office organization, recently asked States and universities to supply information obtained from systematic studies which would help to identify (in terms of age, education, income, and other factors) segments of the population that have been hard to reach for vaccination, and which would help to explain why people accept or fail to accept poliomyelitis vaccinations.

In addition to the formal inquiry, the literature on these topics was searched independently.

Although little time was available for gathering data in preparation for a national meeting to consider the problem, more than 40 research activities on poliomyelitis vaccination were identified. Seventeen of these were found to bear directly on the question of why people accept or fail to accept vaccination for themselves and their families. Of the 17 studies, 13 were reviewed; 4 were unavailable. Seven of the 13 were discarded because of methodological limitations in their design or because they could not be properly evaluated.

The six remaining studies (*1–6*) are methodologically sound and report findings which have implications for planning poliomyelitis vaccination programs. These studies contribute to our understanding of why people accept or reject vaccination. However, except for the Clausen (*2*) and Deasy (*3*) reports, which rep-

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resent different analyses of the same data, the studies were independently done, so that the relationships among the findings are not always clear. We shall attempt, therefore, to crystallize these relationships by analyzing the findings according to one set of explanatory concepts. The interpretations presented here, however, are not fully supported by adequate data in all cases. Additional studies of the explanatory concepts will be required to assess the validity of our interpretations.

From an analysis of the six studies, it would appear that two broad classes of factors determine the decision to participate in vaccination programs. These are personal readiness factors and social and situational factors.

Personal Readiness Factors

The factors of personal readiness include the motives, attitudes, and beliefs of individuals which affect their willingness to take voluntary action with regard to their health. Hochbaum (*7*) has described the importance of these factors in guiding the decision to obtain chest X-rays. In connection with poliomyelitis vaccination, three components of a person's readiness to seek vaccination can be identified: the extent to which he believes he may be susceptible to the disease, the seriousness with which he regards the consequences of getting the disease, and his conception of the safety and effectiveness of the vaccine.

Perceived Susceptibility

It would appear that a basic determinant of the decision to seek vaccination is the extent to which the individual believes that he is susceptible to poliomyelitis, or, for children, the extent to which the parent believes that his child is susceptible.

In Glasser's report of the study made for the National Foundation for Infantile Paralysis (*4*), the absence of perceived susceptibility is cited as 1 of the 2 principal barriers to the decision to obtain vaccination. Merrill and his associates (*5*) show that poliomyelitis tends to be regarded as a disease affecting only children, which may account for the failure of some adults to accept vaccination. The authors suggest that the establishment of vaccination priority groups tended to reinforce this perception among leading people that those included in the first priority group were the only ones who needed vaccination. The familiar picture of the child on crutches may also have reinforced the belief that poliomyelitis is a disease of children.

The failure to believe that one is susceptible to poliomyelitis may be a widespread problem. In the National Foundation for Infantile Paralysis study (*8*), 72 percent of the young adult sample believed that poliomyelitis had been nearly brought under control.

It must be stressed that this variable, perceived susceptibility, refers to the beliefs of people and not to objective facts about incidence. It is known that behavior is determined more by one's beliefs about reality than by reality itself, and that people vary markedly in their interpretations of reality.

Perceived Seriousness

Even when an individual feels he is susceptible to poliomyelitis (or believes that his child is), he will not act on his feeling unless he also believes that his becoming ill would have serious repercussions on his life. Here again it is the belief rather than the reality which is the important determinant of the decision.

While the data on seriousness are not as clear-cut as those on susceptibility, the studies by the National Foundation for Infantile Paralysis and Merrill and his co-workers suggest the importance of this factor in determining one's decision concerning vaccination. In the former study, it is shown that twice as many men as women in a nationwide sample believed that poliomyelitis in adults is milder than in children, and half as many men in the sample had been vaccinated. The latter study shows that the over-40 age group may not see poliomyelitis as constituting a serious problem for adults, and additional data suggest that poliomyelitis is considered to be milder in adults than in children.

Safety and Effectiveness

One's decision to accept vaccination for one's self and one's family is a function not only of the perceived likelihood of contracting the disease and the perceived seriousness of the disease

should it occur, but it is also a function of the kinds of beliefs one has about the safety and effectiveness of vaccination in reducing susceptibility and seriousness.

However concerned one is with poliomyelitis, if he thinks the vaccine is unsafe or ineffective, he will not accept vaccination. In the three studies reviewed which were conducted in connection with the field trials of 1954, questions of safety and effectiveness are frequently mentioned as a factor limiting decisions to participate (*2,3,6*). However, in Glasser's 1957 study (the most recent of the several reviewed), it is shown that such fears have largely been dispelled and no longer seem to be an important factor limiting acceptance of vaccination. It is certainly possible, however, that in specific groups this factor may still be important.

The three variables, perceived susceptibility, perceived seriousness, and beliefs about vaccination, define the kinds of personal factors that influence a decision relative to vaccination. But there is reason to believe (although the authors of the studies reviewed do not discuss this point) that the decision is determined not only by the kind of beliefs one has but by other factors as well.

Again and again the studies reviewed list procrastination, forgetfulness, neglect, apathy, carelessness, and laziness among the factors influencing the decision to vaccinate. These terms are not useful since they neither define a dynamic process nor suggest ways of overcoming the problem. We believe that these terms may be synonyms for one of two kinds of processes.

Clausen (*9*) reports data from California which suggest that there is a social class influence on behavior which is somewhat independent of the three beliefs described above. He shows that even among mothers who are generally favorable to vaccination those with much education and married to white collar workers were much more likely to have their children vaccinated than those with little education and married to blue collar workers. The extent to which such a social class influence operates independently of the kinds of beliefs described above must await detailed study of that question.

It is also possible that "procrastination," "apathy," "laziness," and the like reflect insufficient amounts of readiness to obtain poliomyelitis vaccinations.

It has been noticed that a great many people appear to have minimal motivation with regard to poliomyelitis. Glasser, for example, reports that by and large "people were failing to take advantage of the vaccine for themselves and their children, not because of specific resistance to it, but rather because of lack of definite, positive influences which might direct them to a clinic or doctor's office for inoculations" (*4*).

Limited data suggest that many people may already share the necessary beliefs, but not in sufficient degree. It is likely that those people with more than minimal motivation have already been vaccinated.

Social and Situational Factors

The personal readiness factors influence the voluntary decision to seek vaccination. However, the studies reviewed suggest as well that a variety of situational and social conditions may be effective in stimulating people to seek vaccination even in the absence of appropriate kinds and degrees of personal readiness.

Two components of the social and situational factors may be identified: social pressure and convenience.

Social Pressure

Clausen, Deasy, Glasser, and Merrill (*2–5*) all observe that vaccinated persons are more likely than unvaccinated persons to report discussion of vaccination with friends, in groups such as the PTA, or with physicians. Despite certain difficulties in interpreting this finding, it has at least been demonstrated that considerably more communication and interaction occurs among people who have taken action than among those who have not.

The individual's decision to seek vaccination may be determined by the social pressures applied by persons who are important to him. Belcher (*1*) shows that a greater proportion of Negroes than whites participated in a vaccination program in two Georgia communities. He suggests the importance of the fact that Negro school teachers urged the program among their pupils as enthusiastically as they could. There

is even a hint that the activities of some may have bordered on coercion. Negro ministers, both on and off the pulpit, urged vaccination. Public health physicians and nurses, presumed to be of fairly high status in the Negro community, also urged the people to seek vaccination.

Data presented by Glasser suggest that the physician will have a highly important role in stimulating people to be vaccinated. More than 90 percent of his adult sample looked to the physician as the principal source of information on poliomyelitis. Moreover, an overwhelming majority of unvaccinated persons reported that they would seek vaccination if their physician recommended it, and 80 to 90 percent of this group reported having a regular physician.

Convenience

Included within the notion of convenience is the distance one has to travel to obtain vaccination, the hours at which it is available, the cost of vaccination, and the acceptability of the facilities in which vaccination is performed. For any individual with a given degree of readiness to be vaccinated, the ultimate decision will be facilitated the more convenient, simple, and inexpensive the action is.

In explaining the higher participation rate of Negroes than of whites in the communities he studied, Belcher suggests the importance of the fact that vaccinations were administered at and by the local health department, a facility more widely known and accepted among Negroes than whites, that vaccination was free, and that more school buses were provided to take Negro children to the clinic for vaccination than to take white children.

Readiness and social factors may operate with a degree of independence of each other or they may interact. However, when the personal readiness to seek vaccination is weak, we would not expect the individual to act unless the social and situational forces impinging on him were strong. On the other hand, when relevant social factors are weak or absent, vaccinations would be sought only by persons with considerable personal readiness.

The evidence to date suggests that, among the currently unvaccinated, personal readiness to obtain poliomyelitis vaccination is so weak that rather strong social supports may be needed to modify their behavior in the short run. Educating for increased personal readiness can probably be effective only in the long run.

Obviously, the use of social forces in urging poliomyelitis vaccination entails working with local groups, often in face-to-face contacts. Deasy, Glasser, and Merrill have made this point explicitly, and Belcher has made it implicitly.

Each of the studies reviewed uncovered ignorance or misinformation among the people interviewed, and especially among those who have not been vaccinated. Clausen, Deasy, Glasser, Merrill, and Weiss show that acceptance of poliomyelitis vaccination is closely related to socioeconomic status, primarily education and occupation or income. The majority of the studies reviewed here offer evidence that the groups hardest to reach (the poorly educated and the nonwhite) will have to be approached personally rather than through mass means of communication. This conclusion is supported by research on communications performed on other subjects.

In the following paragraphs, only a few communication studies will be mentioned, although the bibliography is extensive. The role of television can only be referred to; standard books on communications research do not yet include much on the new medium.

Communications Research

It is known that different groups are differently exposed even to the most ubiquitous media. Lazarsfeld and Kendall (*10*) have shown that the lower educational groups do not read newspapers, magazines, and books to the same extent as do groups with more education; they differ little in exposure to movies and radio. However, even when groups are exposed to the same medium, they may attend to and learn different things from the same material.

Schramm and White (*11*) showed that with respect to newspaper reading, lower educational groups tended to read news of crime, corruption, disaster, and sports, whereas the more educated tended to read news of public affairs, economics, science, and social affairs.

Moreover, in a study performed for the National Association of Science Writers (*12*), it was clearly shown that the extent to which one could recall having learned any science or health information from newspapers, magazines, television, or radio was closely related to amount of education. Thus, of a group with less than high school education, more than one-third could recall no health or science information from these media, whereas of the group with high school education, only 11 percent were similarly unable to recall science or health information. At the higher educational levels, virtually everyone was able to recall science and health information from these sources.

Some of the data reported in the poliomyelitis studies support this trend. Belcher found that the nonwhites in his sample obtained their information on poliomyelitis and vaccination from personal sources (teachers, children, public health officials), while whites tended to get their information through impersonal sources. Similarly, Deasy showed that while all women in her sample had been exposed to an identical brochure, which had been brought home by their children, on the 1954 field trials, and while practically all women in the sample had been exposed to daily papers which were featuring intensive coverage of the field trials, the women differed in knowledge and acceptance of the program, acceptance being associated with amount of education.

Katz and Lazarsfeld (*13*) report that people who are reached by educational programs through the mass media are very largely those who do not need the education. Those who do need the education tend to stay away. In their words, "Those groups which are most hopefully regarded as the target of the communication are often least likely to be in the audience. Thus, educational programs . . . are very unlikely to reach the uneducated; and goodwill programs are least likely to reach those who are prejudiced against another group" (*13a*).

It is not to be denied that the mass media have, and always have had, an important role in communication. However, the poliomyelitis and communication studies reviewed here suggest that the assets and liabilities of the traditional approach should be considered in the light of the particular needs that face us in attempting to reach the lower income family, the family with little formal education, and the nonwhite family.

In this context, Merrill and his co-workers, in discussing people who have little money and little formal education, have said, "It appears that there is need for a change in target and methods if we are to reach this group effectively with health education" (*5*).

In a similar vein, Glasser states, "Informal communication—getting people to talk about vaccination—would appear to be the most direct method of accelerating the vaccination program" (*4*).

Summary

A person's beliefs about his susceptibility to poliomyelitis, about the severity of the disease, and about vaccination comprise the major components of his readiness to take action. On the other hand, social forces, including factors of pressure and convenience, are important in guiding the decision to be vaccinated or not.

The data reported tend to suggest that social class membership may affect decisions to be vaccinated and that personal readiness for poliomyelitis vaccination may be weak in those who are currently incompletely vaccinated. If this is so, the social factors would have to be stressed in order to insure more widespread acceptance of vaccination.

In considering the approaches that may be made to reach groups in an attempt to stimulate greater acceptance of vaccination, one is struck with certain serious limitations of the traditional approach of mass media of communication. It would appear that personal contacts with members of the so-called hard-to-reach groups may be required to stimulate increased acceptance of poliomyelitis vaccination.

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film

Use of Anticoagulants in Rodent Control

35-mm. filmstrip, color, sound, 9½ minutes, 76 frames. 1958.

Audience: Federal, State, local, and other health personnel engaged in rodent control.

Providing a comprehensive description of how anticoagulants are employed to kill rodents, this filmstrip shows the advantages of these poisons compared with other poisons. It lists the forms and types of anticoagulants available. It describes the various baits and tells how to prepare them, shows the containers and how to place the poisons to get the most efficient kill. Precautionary measures to be used in handling these materials are emphasized.

This film may be obtained on LOAN from the Communicable Disease Center, Public Health Service, 50 7th Street NE., Atlanta 5, Ga., or by PURCHASE from United World Films, Inc., 1445 Park Avenue, New York 29, N. Y.

Legal note . . . Liability for Air Pollution

Res ipsa loquitur doctrine held applicable in suit for damages resulting from fluoride poisoning allegedly caused by defendant's aluminum reduction plant; defendant's evidence of reasonable care held insufficient to require finding as a matter of law that inference of negligence had been overcome. *Reynolds Metals Company* v. *Yturbide*, 258 F. 2d 321 (9th Cir., June 5, 1958).

The plaintiffs claimed they were poisoned by fluorides originating from the plant of the defendant, the Reynolds Metals Company. Their injuries were found by a jury to have been caused by excessive emission of fluorides by the defendant's plant. On appeal by the defendant the court of appeals, sustaining the verdict for plaintiffs, held that the defendant's evidence of reasonable care in operation of the plant was not sufficient to rebut the presumption that the excessive emission of fluorides was attributable to defendant's negligence.

The defendant operated an aluminum reduction plant in Troutdale, Oreg. In December 1946, shortly after operations began, the plaintiffs moved to a farm about 1 mile from the plant. For a period of about 4 years, a daily average of 2,800 pounds of fluoride was discharged into the atmosphere from the plant, running as high as 3,900 pounds daily in 1 month. In November 1950, when an improved system was installed, the fluoride discharge was reduced to a daily average of 643 pounds.

Although there was no proof of the quantities of fluorides which reached the plaintiffs' land, the court found that the fluorides emitted by defendant's plant were toxic, and it was conceded by the defendant that the fluorides escaping from its plant were poisonous in excessive amounts. The plaintiffs showed that the fluoride effluent reached their property and settled on it, that it was absorbed by vegetables, which were eaten by plaintiffs, that it etched the glass in their home, and that it was presumably inhaled by them. Evidence was also adduced that the plaintiffs' health improved when they moved away from the vicinity of the plant.

The defendant contended that (*a*) the proof was insufficient to demonstrate that the plaintiffs' injuries were caused by fluorides escaping from the plant and (*b*) there was no evidence of negligence or breach of duty by the defendant.

With respect to the first contention, the court held that on the basis of the evidence presented the jury was warranted in finding that the plaintiffs' injuries were caused by the fluorides emitted by the defendant's plant which found their way to the plaintiffs' property. Although evidence was presented by the defendant to show that only a small concentration of fluorides could have reached the plaintiffs, the court ruled that the fact that they suffered fluoride poisoning supported the finding that an "excessive amount" of fluoride, sufficient to cause such poisoning, was cast upon the plaintiffs' property from the defendant's plant.

The plaintiff was unable, however, to specify any particular acts of negligence by the defendant which brought about the injury and was compelled to rely on the legal doctrine of "res ipsa loquitur" (the thing speaks for itself) under which the facts of the occurrence warrant the inference of negligence.

Since the defendant's evidence was to the effect that, despite the large amounts of fluorides it admitted escaped into the air, no significant concentrations of fluorides were produced in localities near the plant, the trial court charged the jury that it was not to be expected that in the ordinary course of events the fluorides emitted by the plant would cause injury in the absence of negligence of the defendant. The court of appeals held that a finding that excessive amounts of fluorides were deposited on plaintiffs' property (a permissible inference from the facts) from the plant whose construction, operation, and maintenance was under the exclusive control of the defendant could reasonably be accepted as circumstantial evidence of negligence.

The court rejected the defendant's argument that this holding resulted in the application of a rule of absolute liability. Although the defendant's evidence tended to show that reasonable care had been exercised to control the amount of fluorides emitted by its plant, the court pointed out that such evidence did not preclude the jury from rejecting the defendant's version of the facts nor from finding that the defendant was in fact negligent.

New laboratory procedures are used for evaluating critical dosage, bait refusal, and speed and variability of action of five poisons against three rodent species. Warfarin is not excelled by other compounds tested, but some others are about equal to it against some species.

Laboratory Studies of

Five Anticoagulant Rodenticides

WAYLAND J. HAYES, Jr., M.D., Ph.D., and THOMAS B. GAINES, B.S.

EARLIER studies on warfarin have emphasized the difference between the newer, anticoagulant rodenticides and the older, quick-acting poisons (*1*). It was evident at the beginning that laboratory tests used for quick-acting rodenticides were not applicable to the newer poisons without modification. Hence, development of a suitable laboratory method for rapid evaluation of the slow-acting rodenticides was an important part of the present studies. The procedures devised, as well as the results obtained with respect to required dosage, bait refusal, and speed and variability of action, are reported in detail.

Materials and Methods

All wild rodents tested were caught by hand in the field and then held in the laboratory on a diet of laboratory chow (*A*) for a minimum of 2 weeks before testing. During each test, the rodents were kept separately in cages of the Army Medical School type. They were offered free choice of (*a*) unpoisoned, ground laboratory chow and (*b*) yellow cornmeal (maize) containing an appropriate concentration of the rodenticide under test. Water was available at all times. Yellow cornmeal was chosen as the food in which to offer the poison because it has proved to be the most generally acceptable, inexpensive bait under field conditions. Laboratory chow was used as the poison-free food because it was the food to which the rodents were conditioned before the tests began and because it is as similar as is practically possible to the mixed diet which rodents receive in nature. Providing the two foods simulates field conditions, as it is generally impractical under field conditions to offer poison to rodents in the same kind of food as that to which they are accustomed. In fact, an effort should be made to offer a bait which the animals will prefer to their ordinary food.

Figure 1, part a, shows cups for offering a choice of food in place at the back of a cage. These cups, with special lids to minimize spillage, are available commercially. They are satisfactory, but experience has shown that wild rats overturn them occasionally. Spring clips were designed to hold the cups firmly in place (fig. 1, parts b and c). These clips, made without special tools from 24-gauge galvanized sheet metal, can be bolted to the back of each cage. The food cups can be easily removed

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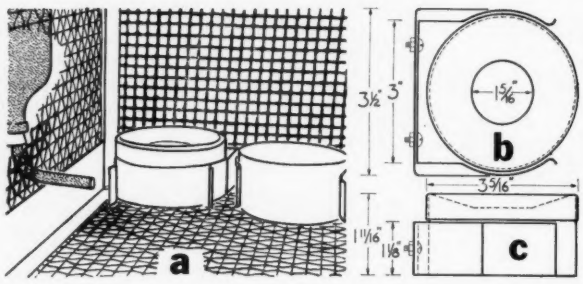
from the clips for weighing, but rodents cannot move them.

These cups, the smallest commonly available from dealers, are too large to use with mice since strong animals frequently get into them, while mice weakened by poison cannot reach the food at all and are thus starved. Cups made from 2-ounce ointment cans proved satisfactory for mice. A hole seven-eighths of an inch in diameter was cut in the center of the metal lid, and the top portion of the lid was then depressed in a conical form similar to that of the larger, commercial models shown in the figure. Special holders for the small cups were not necessary even for wild mice. A disk of ¼-inch mesh hardware cloth was put in each cup to prevent mice from scratching food out. As an added precaution, fresh paper was used in the tray of each cage so that any spilled bait could be detected.

The following rodenticides were studied: warfarin, 3-(d-acetonylbenzyl)-4-hydroxycoumarin; coumachlor, 3-(d-acetonyl-4-chlorobenzyl)-4-hydroxycoumarin; Pival, 2-pivalyl-1,3-indandione; PMP, calcium salt of 2-isovaleryl-1,3-indandione; and Diphacinone, 2-diphenylacetyl-1,3-indandione (*B–F*). Each compound was tested against adults of one or more of the following species: the Norway rat, *Rattus norvegicus;* the roof rat, *Rattus rattus;* and the house mouse, *Mus musculus.* A short supply of animals prevented testing coumachlor against mice or Diphacinone against roof rats or mice.

The dry, poisoned baits were prepared by mixing appropriate amounts of the rodenticide into the bait with an ordinary kitchen-type electric food mixer. For low concentrations of poison (50 ppm or less), the technical grade compound was weighed out carefully on an analytical balance and then, with a mortar and pestle, thoroughly mixed with cornstarch in the proportion of 1 part rodenticide to 99 parts cornstarch by weight. The amount of this rodenticide-cornstarch concentrate required to give the desired concentration of poison in a selected weight of finished bait was weighed out and mixed thoroughly with about one-fourth the necessary weight of cornmeal. The remainder of the cornmeal was then added and mixed to give the final concentration of poison

Figure 1. Equipment for offering a choice of baits to caged rodents.



Part a, food cups held in place by metal clips (cover of one cup removed). Part b, top view of metal clip and food cup. Part c, end view of same clip with food cup in place.

to be tested. For the higher concentrations of rodenticide (100 ppm or more), the procedure was the same except that the proportion was 1 part rodenticide to 19 parts cornstarch. Each separate mixing with the cornmeal required at least 15 to 20 minutes. Coarse, degerminated cornmeal of a quality suitable for cooking was used in all the tests.

Each rodenticide was tested in several of the following concentrations, which form a geometric progression with a factor of one-half: 800, 400, 200, 100, 50, 25, 12.5, 6.3, 3.1, and 1.5 ppm. Chemical analyses showed that it was possible to obtain these concentrations with an error of 0.5 ppm or less. Ten rodents (5 males and 5 females, when possible) were usually used for each test; more than one test was frequently made, especially at the lower dietary concentrations. Each rodent was offered the poison (as well as poison-free food) for a maximum of 40 days. Surviving animals were maintained on laboratory chow until they died or until their survival was assured. The time of death was recorded in all instances.

During the tests, the intake of poisoned bait and of poison-free food was recorded daily for each animal. The animals were weighed once a week. These measurements made possible the calculation, on a milligram per kilogram basis, of the total dosage of rodenticide ingested by each rodent. They also made possible direct comparison of the amount of poisoned bait and of poison-free food taken by each rodent. Bait refusal is conveniently expressed as the average percentage of the total daily

diet during the exposure period which was poison free. As already mentioned, this percentage was intentionally suppressed by offering the poison in an attractive bait. However, the choice of diet used in the test permits rodents to refuse poison completely (bait refusal=100 percent) without undergoing any hunger.

Under practical conditions of use, it is characteristic of poisoning by anticoagulant rodenticides that most of the animals die relatively soon after the first one, but a few linger on for many days especially when the poison is fed at a low concentration. (The initial delay is explained by the pharmacological action of these compounds.) Values skewed in this way tend to be normalized by logarithmic transformation. Therefore, the logarithms of the survival times were used to calculate the geometric mean and 95 percent confidence limits. The antilogarithms of the resulting values were then plotted (together with the observed values) against the concentration of rodenticide in the bait. In all instances, the calculations were based solely on animals which died. However, in those instances in which one or more animals survived the test, the upper 95 percent confidence limit was not plotted because in this situation it is not realistic.

The critical dosage is defined as the smallest average dosage killing a species so rapidly that the upper 95 percent confidence limit for that and all higher average dosages is 45 days or less. (Usually, the critical dosage was identical to the smallest average dosage which killed all rodents tested.) The dietary level of poison consumed by those rodents which received the critical dosage is designated the critical concentration.

The average bait refusal of rodents offered four times the critical concentration is selected as the value for comparison of one species with another and of one poison with another. The factor of 4 is used so that comparisons may be made for dietary levels suitable for field use. It has been observed, within the geometric progressions of dosages studied, that a factor of 4 compensates adequately for irregularity in consumption of bait and other ill-defined variables which characterize the use of rodenticides in the field. Thus, a factor of 2 is too small, and a factor of 8 is unnecessarily large. For the same reason, the geometric mean for time-to-kill (in days) for rodents offered four times the critical concentration is selected as a comparative value for the speed of action.

The variability of action is defined as the difference (in days) between the geometric mean and the upper 95 percent confidence limit of the time-to-kill for rats fed four times the critical concentration. This method of expressing variability of response gives practical information about the period necessary to kill a species with a particular poison. The variabilities of dosage and bait refusal tend to be correlated; however, they are of less practical interest and are not presented in this paper.

Results

The results in regard to dosage are presented for all compounds and all species tested in table 1. Corresponding results on bait refusal and speed of action are given in figure 2. Some indication of the variability of action of each poison also may be inferred from the figure.

The data in table 1 indicate that the critical dosage is truly characteristic of the action of a particular poison in a particular species. For example, the critical dosage of warfarin for wild Norway rats was 4.2 mg./kg., corresponding to a concentration of poison of 12.5 ppm; yet even over the wide range of concentration of poison of 1.5 to 50 ppm the average dosage showed the narrow range of 2.3 to 6.8 mg./kg. The critical dosage of warfarin for the roof rat was 18.1 mg./kg., a value distinctly different from that for the Norway rat.

The dosage of any of the rodenticides tested necessary to kill the three common commensal rodents is small; however, as shown in table 1 and in figure 2, the three species differ strikingly in their response to the rodenticides. In general, the Norway rat was most susceptible, as judged by dosage and survival time, and the roof rat was least susceptible. Furthermore, the roof rat tended to show greater variability of response than the Norway rat. The house mouse resembled the Norway rat in susceptibility but the roof rat in variability. Thus, the results determined for one species cannot be applied with precision to another.

Table 1. Dosage of anticoagulant rodenticides consumed by rodents when offered

Species and concentration of poison in bait (ppm)	Warfarin				Coumachlor			
	Total dosage		Number of animals tested	Percent mortality	Total dosage		Number of animals tested	Percent mortality
	Range (mg./kg.)	Mean (mg./kg.)			Range (mg./kg.)	Mean (mg./kg.)		
Wild Norway rat								
800	6. 8– 173. 2	96. 7	10	100				
400	7. 8– 88. 0	37. 4	10	100				
200	1. 3– 51. 3	28. 8	20	100				
100	11. 8– 21. 0	15. 7	10	100				
50	1. 0– 11. 5	6. 8	10	100	3. 7– 12. 8	**9. 0**	10	100
25	2. 4– 5. 9	4. 7	10	100				
12.5	2. 5– 10. 9	**4. 2**	10	100	2. 9– 14. 9	5. 9	10	90
6.2	0. 8– 4. 5	2. 6	19	95				
3.1	0. 1– 6. 8	2. 3	20	95	0. 8– 5. 5	1. 6	10	90
1.5	0. 9– 7. 9	3. 3	10	50				
Roof rat								
800	1. 4– 391. 6	168. 0	30	100				
400	20. 7– 105. 0	71. 4	10	100	39. 8–215. 0	112. 5	10	90
200	11. 3– 142. 5	52. 8	30	100	46. 1–152. 5	66. 3	10	100
100	4. 1– 54. 7	21. 4	10	100				
50	7. 4– 48. 2	**18. 1**	10	100	20. 2–107. 0	71. 7	10	30
25	3. 1– 34. 4	11. 9	10	80				
12.5	3. 3– 5. 7	3. 8	10	70				
3.1								
House mouse								
800	52. 0–1536. 0	328. 0	30	100				
400	58. 8– 498. 6	198. 7	10	100				
200	34. 0– 512. 0	95. 0	30	100				
100	23. 3– 170. 7	60. 2	10	100				
50	16. 8– 43. 8	33. 9	10	100				
25	6. 8– 33. 3	15. 5	10	100				
12.5	3. 3– 8. 7	**5. 5**	10	100				
6.2	1. 0– 19. 0	8. 9	9	89				
3.1	0. 5– 9. 1	4. 3	10	100				

NOTE: Critical dosages, as defined in text, are in boldface type.

There is evidence, both from a high degree of bait refusal and from an increase in bait refusal with increasing concentration, that PMP is detected by wild Norway rats and by mice. There is some evidence, from an increase in bait refusal with increasing dietary concentration on the first day of exposure, that both species of rats may detect the higher concentrations of warfarin. However, all three species tended to adjust to the flavor of the rodenticides so that secondary bait refusal was not significantly greater and was occasionally slightly less than the corresponding primary bait refusal. (Secondary bait refusal, also called "bait shyness," consists in a learned response frequently based on illness induced by a poison.) Thus, the anticoagulants contrast strongly with the fast-acting rodenticides, which lead to more serious primary bait refusal and especially to almost complete secondary bait refusal. This observation does not contradict the fact that, as rodents became progressively poisoned with anticoagulants, they ate less and less food of both kinds.

Within groups in which all animals died, special analysis was made of the animals which survived more than 14 days. Study of the individual records showed that, with rare exceptions, all animals of the three species which survived more than 2 weeks took substantial

poisons at different concentrations in bait and with a free choice of unpoisoned food

PMP				Diphacinone				Pival			
Total dosage		Number of animals tested	Percent mortality	Total dosage		Number of animals tested	Percent mortality	Total dosage		Number of animals tested	Percent mortality
Range (mg./kg.)	Mean (mg./kg.)			Range (mg./kg.)	Mean (mg./kg.)			Range (mg./kg.)	Mean (mg./kg.)		
0. 0–164. 0	64. 0	10	80								
0. 0– 91. 0	39. 0	20	90					23. 6– 61. 6	45. 4	10	100
15. 0–106. 0	42. 0	20	85								
7. 3– 48. 3	25. 5	9	100	3. 8–12. 3	8. 5	10	100	6. 0– 18. 6	**10. 3**	10	100
12. 5– 55. 6	37. 6	10	30					3. 8– 29. 9	9. 8	10	90
				1. 8– 4. 1	**3. 1**	9	100	1. 5– 22. 0	10. 8	10	90
				1. 1– 2. 4	1. 9	10	90				
				3. 4– 5. 2	2. 0	19	95	2. 8– 8. 0	6. 5	10	10
				0. 0– 3. 3	1. 6	10	40				
140. 0–432. 0	256. 0	10	80								
98. 0–184. 0	154. 0	10	100								
24. 0–272. 0	81. 0	9	89					31. 9–156. 0	61. 6	10	100
22. 5–205. 0	81. 0	10	70								
23. 3– 93. 8	68. 5	10	30					10. 4– 32. 1	**17. 0**	10	100
								1. 2– 24. 8	8. 0	10	100
								0. 4– 7. 7	3. 4	9	67
172. 0–708. 0	292. 0	10	90								
20. 0–222. 0	100. 0	10	90								
61. 0–225. 0	114. 0	10	100					7. 2– 33. 6	15. 2	10	100
27. 0– 86. 5	51. 5	10	100								
25. 5–148. 3	61. 8	10	70					2. 2– 8. 5	4. 3	10	100
								4. 9– 14. 4	8. 8	10	100
								1. 8– 13. 2	**4. 3**	10	100

NOTE: Critical dosages, as defined in text, are in boldface type.

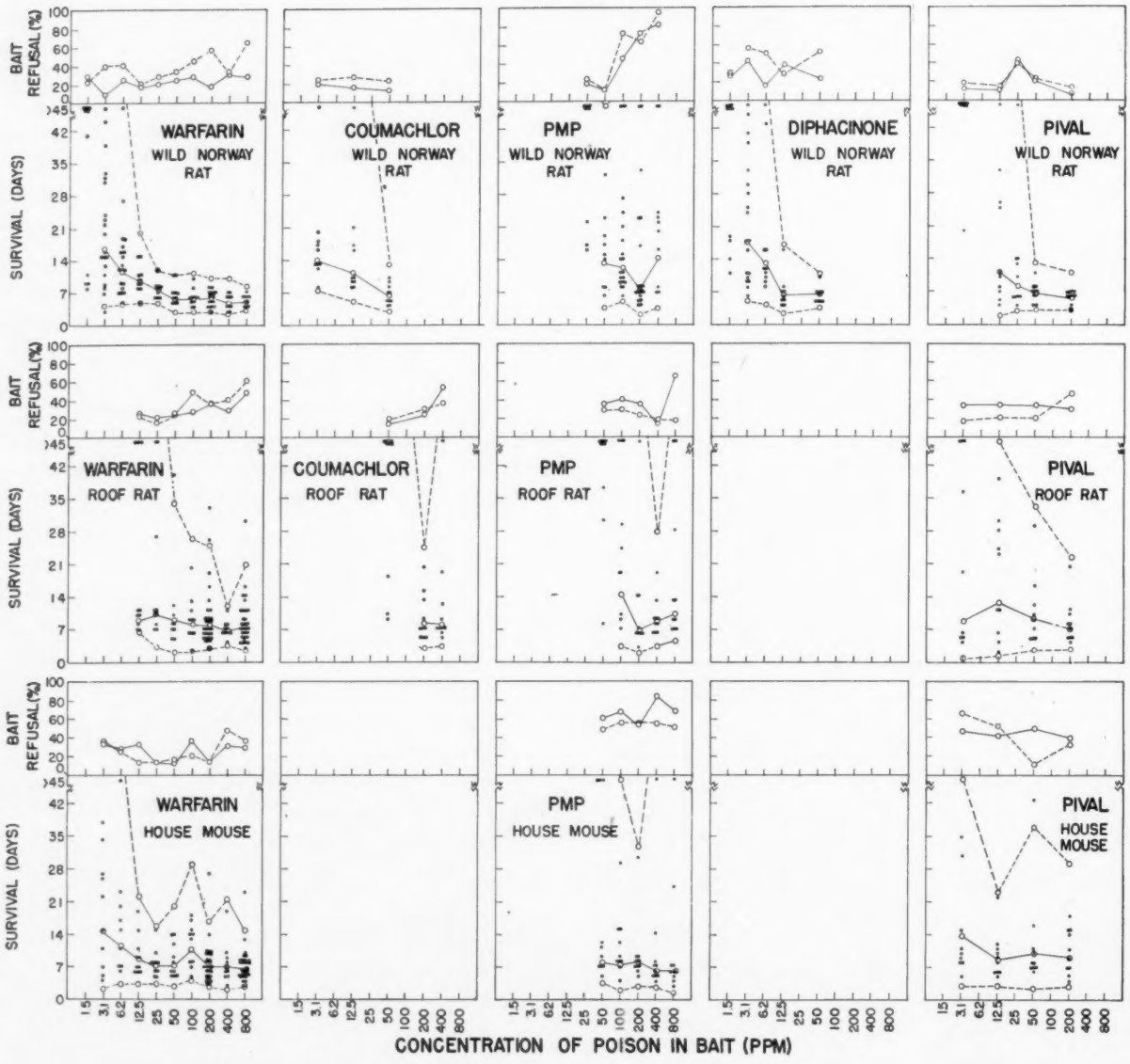
amounts of poison; in fact, their longer survival permitted them to take, on the average, slightly greater total dosages than corresponding rodents which died sooner. Further, most of the rats and mice which survived more than 2 weeks took poison promptly when it was first offered. The few exceptions were refusals of PMP for 21 days or more, with the result that the animals did not receive an adequate dosage. It must be concluded that the unusually long survival periods of a few rodents exposed to effective bait concentrations usually were caused by unexplained properties in the metabolism of the individual animals and not by their failure to ingest poison.

The time necessary to kill the first rat in a group was remarkably similar for the poisons studied irrespective of the concentrations at which they were fed. This is explained by the mode of action of the compounds. Death is the result of hemorrhage following the loss of "prothrombin" activity in the blood. A minimum period of time is required for the activity to be reduced and then for adequate hemorrhage to occur. This is true even in animals which suffer cerebral hemorrhage as well as those which die in the usual way from shock following more extensive bleeding at less critical sites. It appears from figure 2 that the average survival time of wild Norway rats fed

warfarin is not shortened to a practical degree by increasing the concentration of poison in bait above the minimum necessary for effective control. The same is probably true of other rodents and other anticoagulants; however, application of the principle to roof rats fed warfarin was obscured because of the great variability in the response of that species and in other instances because few of the bait concentrations tested were above that which is minimal for control.

Analysis of the data revealed no differences in susceptibility based on sex in any of the three species studied. None of the females was pregnant. Earlier tests have shown that pregnant animals exhibit an increased susceptibility (*1*).

Figure 2. Bait refusal and survival time of rodents offered unpoisoned food and various concentrations of rodenticides in bait.



BAIT REFUSAL (percentage of total food intake which was unpoisoned) : Dashed line, first day of experiment. Solid line, entire experiment.

SURVIVAL TIME: Dots, survival time for each rodent. Open circles connected by solid line, geometric mean for the time of death of rodents that died; open circles connected by dashed line, 95 percent confidence limit.

Table 2. Critical dosage, bait refusal, speed of action, and variability of action characteristic of anticoagulant rodenticides

Species and rodenticide	Critical dosage (mg./kg.)	Critical concentration (ppm)	Bait refusal (percent)	Mean speed of action (days)	Variability of action (days)
Wild Norway rat					
Warfarin	4. 2	12. 5	25	5. 8	5. 1
Coumachlor	9. 0	50. 0	[1] 12	[1] 6. 1	[1] 6. 8
PMP	>64. 0	>400. 0	[2] 82	[2] 14. 1	[2] 38. 0
Diphacinone	3. 1	12. 5	22	6. 3	4. 4
Pival	10. 3	50. 0	7	5. 7	5. 0
Roof rat					
Warfarin	18. 1	50. 0	36	8. 0	15. 6
Coumachlor	>112. 5	>400. 0	[2] 54	[2] 8. 1	[2] 12. 4
PMP	>256. 0	>800. 0	[2] 64	[2] 10. 4	[2] 13. 0
Pival	17. 0	50. 0	30	7. 4	14. 7
House mouse					
Warfarin	5. 5	12. 5	12	7. 7	12. 4
PMP	>292. 0	>800. 0	[2] 68	[2] 6. 3	[2] 17. 3
Pival	4. 3	3. 1	42	8. 6	14. 5

[1] Determined at the critical concentration because no test was run at four times the critical concentration.
[2] Determined at the highest dosage tested because a dosage satisfying the definition of critical dosage was not found.

NOTE: For each characteristic, a low value is favorable.

Of the several poisons tested, only warfarin was tested against Wistar strain albino Norway rats, with the same experimental procedures. The results (tabulations not shown) were so very similar to those for the wild Norway rat that for practical purposes they could be substituted for them.

A few new observations on pathological changes caused by warfarin supplement those reported earlier (*1*). A very few rodents poisoned by warfarin show paralysis of the hindquarters for a variable period before death. In every instance encountered so far, this sign of illness has been explained by the finding at autopsy of limited hemorrhage in the central nervous system. A few other rodents die rapidly without the development of paralysis as the result of more massive cerebral hemorrhage.

Mice show a distinctly different pathological condition from that observed in the two species of rats. Slightly more than half of 105 mice examined showed a profuse, thin, serosanguineous exudate into the pleural cavity. Both the character and location of this exudate differ from anything consistently seen in rats.

The results of this study, summarized in table 2, appear to justify the following conclusions. The performance of warfarin against the commensal rodents was not excelled by the other anticoagulant compounds tested. Diphacinone was about as good as warfarin against wild Norway rats. Pival was about equal to warfarin against roof rats and mice but, like coumachlor, somewhat inferior against wild Norway rats. In comparison with the other rodenticides tested, PMP was distinctly inferior against all three species of commensal rodents.

Discussion

The method of laboratory testing described is adapted especially to the bioassay of rodenticides in instances in which both the toxicity and the acceptability of the material are under study. Use of the method for estimating proper concentrations of slow-acting poisons against a given species of rodent should obviate field testing of inappropriate concentrations.

Several papers dealing with testing of anticoagulant rodenticides have been published (*2–12*). However, we believe that the method described here yields more complete and more practical information than do earlier methods.

Laboratory tests in which the rodents are fed

poison on alternate days only were considered. Norway rats fed warfarin on alternate days survived slightly longer than those fed the same concentration of the poison *ad libitum* because there was a delay in acceptance of the poisoned food when it was offered on alternate days. Crabtree (*2*) and Bonnet and Gross (*6*), in tests with warfarin against Norway rats, found that the result was the same whether the rats were fed the p son *ad libitum* or on alternate days. On the other hand, *Rattus hawaiiensis* survived twice as long when fed warfarin on alternate days as when fed *ad libitum* (*6*). In any event, when poison is offered on alternate days only, the test is complicated by baiting problems so that it becomes more difficult to know which variables are being measured.

Every effort should be made to determine rodenticide dosages which are effective and, at the same time, as cheap and safe as possible. The use of unnecessarily high dosages may compensate in part for careless mixing of the bait, poor bait distribution, and inferior technique generally, but adds to the expense and to the hazards inherent in the use of rodenticides.

In one of the original studies (*13*) on the analogs of 3, 3-methylene bis(4-hydroxycoumarin), the compound now known as warfarin was shown to have less activity than some of the other compounds when tested against rabbits. When many of the analogs were tested later against Norway rats, warfarin proved to be the most promising of the group. Since species differences do exist, it appears quite likely that, if the analogs were tested systematically against the roof rat, a poison more nearly suited to that species might be found.

Summary

A new laboratory method was devised for the rapid evaluation of multiple-dose, slow-acting rodenticides with respect to required dosage, bait refusal, and speed and variability of action. With this method, it was found that, in general, wild Norway rats are most susceptible and roof rats least susceptible to each anticoagulant compound tested. Wild mice tend to resemble Norway rats in susceptibility, but they resemble roof rats in the high variability of response. The performance of warfarin was not excelled by the other anticoagulant compounds tested, although coumachlor, Diphacinone, and Pival were each about equal to warfarin against 1 or 2 species. PMP was distinctly inferior in performance. A short supply of animals prevented testing coumachlor against mice or Diphacinone against roof rats or mice.

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Specialized Training Courses in Environmental Health

The following courses are scheduled for March 1959 by the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio:

March 2–13. Basic Radiological Health. Fundamental technical knowledge needed for radiological health work, with stress on basic nuclear physics and chemistry. Prerequisite for several other courses.

March 2–13. Water Quality Management: Sanitary Engineering Aspects. Intensive training for sanitary engineers and others active in administration of water-quality management programs. Biological, chemical, and bacteriological phases included. Assignment to discussion panels made prior to the course on the basis of experience and interest.

March 16–20. Physical Analysis of Atmospheric Particulates. Emphasis on properties and physical behavior of particles and methods of sampling and evaluation. Laboratory exercises used in application of techniques.

March 16–25. Environmental Health Aspects of Nuclear Reactor Operations. Introduction to environmental health and safety aspects of nuclear reactor operations, especially off-site problems. Includes 3-day tour of reactor and waste disposal facilities at Oak Ridge National Laboratory, with lectures by ORNL personnel. Prior completion of basic radiological health course required.

March 23–27. Analysis of Atmospheric Inorganics. Broad, technical coverage of qualitative and quantitative analysis of pollutants, with emphasis on applicability and limitations of present methods. Includes laboratory practice.

Address applications to the Chief, Training Program, Robert A. Taft Sanitary Engineering Center, Public Health Service, 4676 Columbia Parkway, Cincinnati 26, Ohio, or the medical director in a regional office.

Signs and Symptoms

of trends in public health

The Medicine Man is a new 27-minute sound film on food faddism and nutritional quackery. Prepared by the American Medical Association from Food and Drug Administration cases, the film depicts a television commentator's investigation of two types of nutrition "quacks": the "health" food lecturer and the door-to-door supplement salesman who makes unwarranted claims for his product.

« »

A graduate Institute of Nutritional Sciences has been established at Columbia University for worldwide training of experts to combat malnutrition. Public health, science, and Ph.D. degrees will be offered, with opportunities for laboratory, clinical, and field research.

« »

Japan reports 1,558,000 births in 1957, compared with 2,678,000 in 1947.

« »

Iowa's campaign to "Save 100 Lives" a year has been such a success that insurance companies are cutting their rates. In 1 year, the traffic death toll was reduced by 21.7 percent, and during the last 5 months in 1958 automobile crashes were 10 percent less than in the same period in 1957.

« »

A report by the House Committee on Government Operations says the American consumer is being bilked out of $100 million annually in the sale of so-called weight-reducing products.

The number of States and Territories with programs for mentally retarded children has grown from 4 to 44 in the last 3 years, the U. S. Children's Bureau reports.

« »

The need for more discrimination in the use of penicillin was cited in the *Chronicle of the World Health Organization*, September 1958. The report calls for education of medical personnel and the public and for regulatory restrictions of sales. From 1943, when penicillin came into general use, through 1957, some 1,000 deaths from anaphylaxis due to penicillin occurred in the United States alone.

« »

Arthritis sufferers with employment difficulties are for the first time being taught various jobs required in hospital operation. The 3-year $100,000 vocational rehabilitation program is run by the New York Arthritis and Rheumatism Foundation in cooperation with the Long Island Jewish Hospital of New Hyde Park.

« »

What We Should Know About Alcohol, a manual for teachers and group leaders by Mildred H. Weiss, clinical psychologist, Cleveland Center on Alcoholism, is offered for use with slides on alcohol education, by the Cleveland Health Museum.

« »

Antimony in lemonade stored overnight in a cheap, enamelware pitcher poisoned 100 picnicking children, reports the Philadelphia Health Department.

When health officers apply for the commitment of mental patients to hospitals, the applications are expeditious and inexpensive, avoid court procedure, and are less traumatic for patient and family, the Butte County (Calif.) Public Health Notes reports.

« »

Following a report indicating that ground water supplies were being contaminated by synthetic detergents from cesspools in heavily populated areas, the Suffolk County Health Department (New York) tightened controls over the digging of private wells. No building permits will be granted without health department certification in areas which have no public water supply.

« »

Private-duty nurses in Washington, D. C., were authorized by the Graduate Nurses Association to raise their basic fee to $18 for 8 hours service on October 1. The new schedule does not authorize extra charges for special cases or for evening duty.

« »

A new edition of the New York State Department of Mental Hygiene's Blondie calendar covering the years 1959–60 is now available for general distribution. The calendar contains 12 mental health messages, to be applied to daily experience.

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Ecology of Foxes and Rabies Control

DAVID E. DAVIS, Ph.D., and JOHN E. WOOD, Ph.D.

A 5-year study of fox populations in the southeastern United States was undertaken to provide information applicable to the prevention of rabies. The research was designed to accomplish at least six objectives: to estimate numbers of foxes, to determine reproduction and death rates, to examine the extent of movement, to determine the prevalence of rabies in a random sample of foxes, to evaluate procedures for controlling their numbers, and to suggest possible trends in fox populations in the future. Results of the investigation, presented in detail in a series of papers in specialized journals (*1–6*), are here summarized and interpreted from the public health point of view.

The research was conducted in Georgia, Florida, and South Carolina, with Thomasville and Newton, Ga., as bases. This area was chosen for several reasons. First, rabies has occurred in these States for many years. Second, vegetation is typical of a great region from Virginia to Texas and thus findings should have wide applicability. Third, the Communicable Disease Center of the Public Health Service had in this area a laboratory which would provide certain services.

The basic philosophy of the research was that foxes are an integral part of the biological economy and should not be exterminated even if this were feasible. It was believed, however, that their numbers should be held below a density at which rabies will occur and that control activities should keep the population below this threshold.

Dr. Davis is associate professor, division of vertebrate ecology, Johns Hopkins University School of Hygiene and Public Health, Baltimore, Md. Dr. Wood, formerly research associate in the division, is now associate professor at Jacksonville University, Jacksonville, Fla.

The research reported here was conducted under Grant E1040 from the National Institutes of Health, Public Health Service.

Census and Vital Data

The first step was to estimate numbers of foxes. A standard procedure of setting traps which permitted calculation of a simple relative census was developed (*1*). A number of traps were set according to specific rules. The traps were placed along dirt roads at intervals of 0.2 mile and examined each morning for 7 days. The proportion of stations that caught 1 or more foxes in 7 days was calculated (*2*). Thus, one trapping area might have a value of 0.15 and another of 0.30. These proportions are only relative measures. They simply indicate differences in number of foxes caught; they do not reveal absolute numbers of foxes. To determine absolute numbers of foxes, rather elaborate and expensive procedures are necessary (*3*). Fortunately, in most practical work a relative method is sufficient to indicate changes.

Since the number of foxes caught depends on movement as well as abundance, the trapping proportions can be used for comparisons of abundance only during periods when movements are constant (as measured by tracking patterns) or between areas of similar habitat. From several lines of evidence it seems clear that greatest movement occurs in the fall in this region. In six areas foxes were trapped in summer after the young were at large and again in the fall. The proportion of stations catching foxes was 0.09 in the summer and 0.18 in

the fall, but most of the increase in the index was due to increased travels of the foxes within their home range (*3,5*). In three large areas where movements were known as a result of capturing, marking, and releasing foxes, an increase in the number caught occurred in October and November.

The rate of increase of a population must be known in order to appreciate the efficacy of a reduction procedure or the recovery of a population after a natural calamity. Our research found that gray foxes averaged 4.5 embryos per female, that 96 percent of the females bred successfully, and that parturition occurred primarily in March and April (*4*). From these results we estimate that a population of 100 foxes in March will produce about 215 pups at birth. (We found no intra-uterine mortality.)

The rate of decrease of a population is equally important in evaluating numerical changes. To determine the mortality rate of foxes, a method of estimating age by tooth wear was developed (*4*). This permitted calculation of probability of dying from the age composition of various samples, using certain well-known assumptions. From these results it was found that the annual probability of dying is about 0.5 (annual death rate per fox=1.3). The life expectancy of an adult fox is 1.5 and that of a pup is about 0.9 years.

These mortality rates are surprisingly high, but they are coupled with a high rate of reproduction to produce a high proportion of young foxes in the population. In five areas in Georgia, Florida, and South Carolina, in which foxes were trapped in the winter, the percentage of foxes less than 1 year old varied from 48 to 61, and only 4 percent were more than 3 years old. The important conclusion here is that the fox population is essentially an annual crop. Control procedures and conclusions about prevalence of virus must recognize this situation.

Precise data on movement of foxes are difficult to obtain, but the question was explored by trapping foxes, tattooing a number in their ear, and releasing them in the expectation that some would be caught again and thus reveal some information about their movements. From the results it was clear that some foxes avoided recapture, but 56 were captured again. More than half of these were recaptured within a mile of the point of release. An aspect of considerable importance is the tendency of foxes to remain together in groups, presumably familial (*3*). These groups disperse in early fall, and this dispersal apparently sets the stage for high mortality of pups.

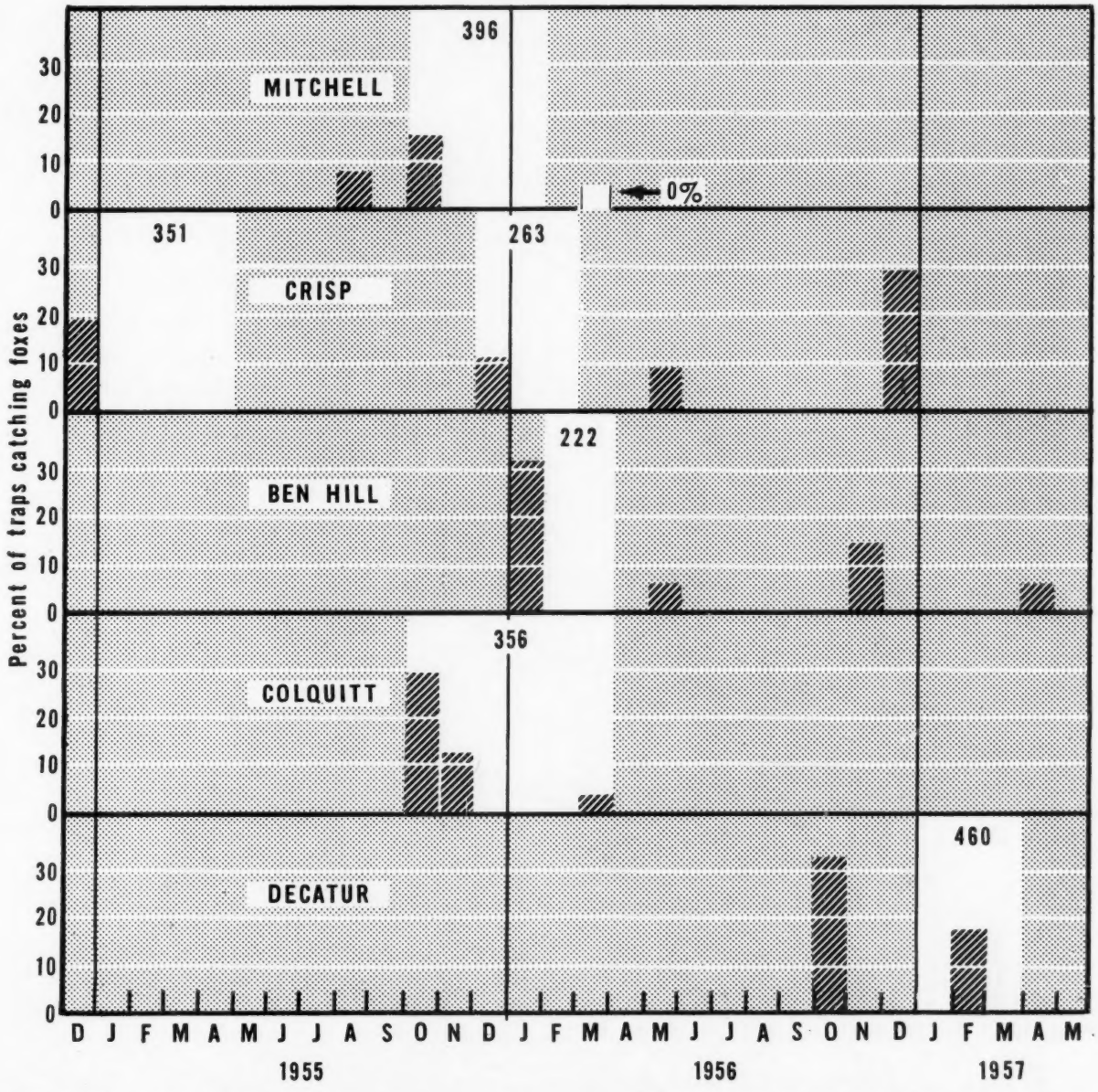
The relation of abundance of foxes to type of habitat is crucial to understanding current distribution and predicting future trends. Detailed analysis of trapping results shows clearly that foxes are most abundant in areas supporting cultivation (*2*). The population indexes were: cultivated areas, 0.22; savannah pine, 0.15; woods, 0.06. The agricultural trend in recent years has been from cultivated areas to woods (for pulp and timber) and pasture. This change greatly reduces the suitability of the area for foxes and should result in a decline in numbers.

Rabies Virus Prevalence

The prevalence of the rabies virus in the fox population was determined by examination of all fox heads from certain areas. This work was done at the Communicable Disease Center laboratory at Newton, Ga., under the general direction of Dr. Ernest Tierkel. Of 1,026 foxes, 32, or 3.1 percent, were found positive for rabies by virus isolation techniques (*6*). No statistical difference in prevalence between gray and red foxes was apparent, for 2 of the 117 red foxes were positive. None of the 299 raccoons or 215 opossums trapped was positive, but 1 of 89 bobcats and 1 of 144 skunks were positive.

The prevalence of the rabies virus differed, of course, from place to place. The data were analyzed to see whether the results could be useful in predicting an outbreak of rabies. The only practical geographic unit for this analysis was the county. In 5 counties that had not reported rabies in either man or animals for many years, none of the 133 foxes was positive. In 2 counties 2 rabid foxes were reported after an absence of reported rabies for 5 years, but examination of 93 foxes in these counties caught in 9 periods revealed no positive foxes. Ten counties had regularly reported rabies in humans or livestock for several years, but in

Population index (proportion of trap stations catching foxes) before, during, and after a specified number of foxes were removed by trapping, five counties in Georgia.



WHITE AREAS: Periods during which foxes were removed by trapping. FIGURES IN WHITE AREAS: Number of foxes removed.

7 of these no positive fox was found in one trapping period when samples of from 9 to 83 foxes per county were examined. In the other 3 counties, 3.5 percent of 28, 11.3 percent of 62, and 8.8 percent of 147 foxes were positive for rabies.

These results demonstrate clearly that the detection of rabies in foxes by trapping on a sampling basis is not a sufficiently sensitive technique to be useful in predicting a rabies outbreak. The basic problem, of course, is that rabies occurs at a high prevalence in a few small areas. Thus, while in a large area only 3 percent of the trapped animals may have detectable virus, there may be many positive foxes localized in a few small habitats. Detection of rabies in foxes is very difficult under these circumstances.

The next step in the search for an indicator of future epidemics was to examine the density

of foxes in relation to prevalence of rabies virus. The results in 24 locations showed no obvious relation between our measure of fox abundance and prevalence of rabies in the foxes. In 11 places where the prevalence varied from 2 to 33 percent, the abundance index (proportion of trap stations catching foxes) varied from 0.10 to 0.51. In 13 locations where no virus was demonstrated, the index varied from 0.06 to 0.40. Actually, there were significantly more captures in localities with recently reported rabies (0.29) than in those without recently reported rabies (0.22).

From this examination we conclude that neither the detection of virus in foxes nor the density of population of foxes is practical as a predictive measure. We thus accept the reporting of cases of rabies in animals and humans as the most promising method of maintaining surveillance of rabies, and we suggest greater emphasis on completeness and accuracy of reporting.

Evaluation of Control Methods

The next question for our research was, what are the most practical and most effective means of reducing fox populations? It is generally recognized that the best way ecologically to control a population is by manipulation of the habitat. Data summarized above suggest that the trend in the southeastern United States from small fields to forests or pasture will produce a reduction in foxes. Fortunately, this trend is expected to continue, but no other feasible habitat change is apparent.

The only alternative to habitat manipulation is killing foxes. Use of poisons should be rejected at once because it is nonselective. Trapping is feasible, and this method has been used for many years. Its effectiveness, however, needs more examination.

Records are available in five counties for the fox population before, during, or after a reduction program by conventional trapping methods (see chart). In four counties (Mitchell, Ben Hill, Colquitt, and Decatur) reduction in the fox population was substantial. In the fifth county, some reduction was obtained, but the population increased subsequently.

Summary and Conclusions

In summarizing the data on fox populations applicable to the prevention of rabies, these points deserve emphasis.

Because of high birth and death rates, fox populations are essentially an annual crop. Thus, there are many new, susceptible foxes each year, and increase in numbers, even after a reduction, may be rapid.

Examination of prevalence of rabies virus in foxes or of abundance of foxes when conducted on the small scale that seems feasible is not sufficiently sensitive for predicting rabies outbreaks. Thus, the reporting of human and animal cases is still the best method of warning that preventive measures are desirable.

Trapping foxes will reduce their numbers, but the effect of such reductions on prevalence of rabies in the fox populations is yet to be determined. The agricultural trend in the southeastern United States from small farms to large tracts of timber or pasture should reduce fox numbers and consequently the amount of rabies.

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Developments in nuclear science in the past decade have demonstrated many ways of putting radiation to use in solving classic problems in such fields as hydraulics, water quality, insect control, food preservation, and air pollution.

Applications of Radiation in Sanitary Engineering

D. A. PECSOK, M.S., H. P. KRAMER, M.S., and D. W. MOELLER, Ph.D.

DURING the past decade the sanitary engineer has frequently assisted in solving problems associated with environmental surveillance of radioactive materials and their management and disposition. Often his studies of such problems have indicated beneficial uses of these materials. For example, studies of specific radionuclides contained in radioactive wastes have provided information on groundwater flow. Similarly, application of water treatment methods to decontamination of radioactive liquid wastes has demonstrated mechanisms of water coagulation and softening.

Encouraged by such results, the sanitary engineer in more recent years has been making direct applications of radioactive materials to the solution of classic problems. Although use of radionuclides in sanitary engineering is still far from routine, a sizable number of applications have been reported and others are in prospect.

Hydraulics

Traditionally, flow characteristics imposed by pipes, tanks, and other boundary conditions are determined by use of a stable tracer material such as sodium chloride or fluorescein dye. Such material does not always yield measurements sufficiently sensitive for accurate tracing of flow paths. On the other hand, radionuclides, evaluated for use under widely varying conditions, provide a highly sensitive technique for this purpose (fig. 1). No single radionuclide has proved ideal for all purposes, selection depending on several key factors:

1. Half-life of the radionuclide. It should be sufficiently long for practical application and sufficiently short for safe disposal.
2. Suitability for measurement by laboratory or field equipment.
3. Safety of personnel conducting the study and others who may be exposed.
4. Physical, chemical, and biological compatibility with the fluid.

For convenience in reviewing the various hydraulics studies of radioactive tracers, the following broad groupings have been made.

Pipe Flow

Radionuclide tracers for measuring fluid flow in pipes have found wide application in the pe-

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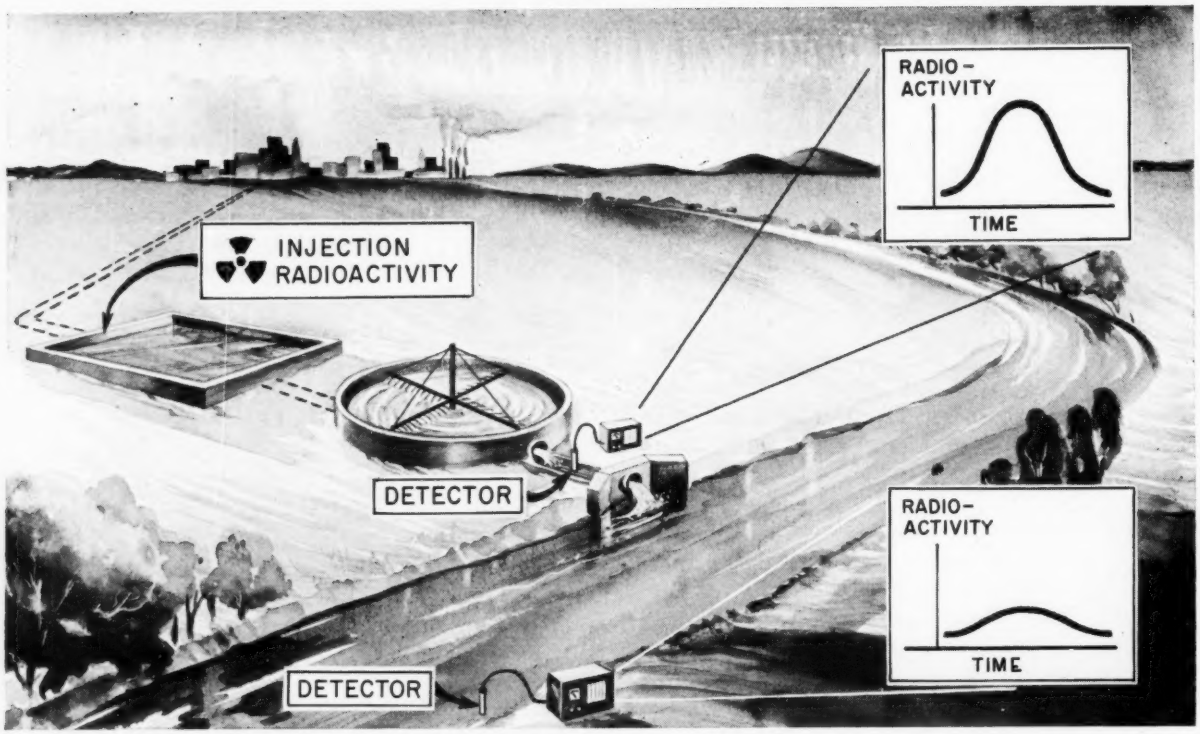


Figure 1. Hydraulics: Use of radiation in flow measurements aids study of tank design.

troleum industry. Their use enables flow measurement outside the pipe without disturbing flow conditions.

Studies on the longitudinal mixing of water in pipes, employing iodine-131, were reported as early as 1950 (*1,2*). The flow time within a milk pasteurization unit (short-time, high-temperature type) has also been evaluated with iodine-131 (*3*). Natural radon and added radium tracers have been used in studies of sewage flow (*4*) and outfall (*5*).

Leaks have been located in newly installed water mains through use of sodium-24. With this nuclide, a counting probe placed close to a pipe junction can detect leakage of as little as 100 milliliters (*6*). Unless the detector can be placed close to the leak, however, such methods are impractical. For example, to detect a leak 5 feet under ground would require a source strength equivalent to 3 curies of cobalt-60.

Tank Flow

Various radionuclides have been used successfully in determining detention time and dispersion in tanks. Radium was used by Hess in 1943 (*7*), but is no longer recommended because of its high cost and toxicity. Today, manmade radionuclides such as sodium-24 (*8*) and potassium-42 (*9*) are being used for measurement of detention time in industrial plant systems.

For tracing sewage flow, biological compatibility of the tracer material is a principal factor. Rubidium-86 is most commonly employed, the first report of its use appearing in 1953 (*10*). In a comparative study of rubidium-86 and bromine-82, the flow characteristics of an anaerobic sewage treatment plant were determined (*3*). Similar results were obtained with these radionuclides.

The dispersion of sewage in a 2-acre lagoon has also been determined. Here, with portable field instruments, iodine-131 tracer was measured (*11*).

Radionuclides are also being used in measureing silt at the bottom of large bodies of impounded water. The technique is based upon a density gauge which detects low-energy bremsstrahlung radiation (*12*).

Watercourse Characteristics

Many factors influence the diffusion characteristics of stream flow. Radionuclides have

proved effective in the determination of stream flow patterns. Use of radium for this purpose was first suggested by Joly in 1922 (*13*). In recent years, radioactive materials have been used for evaluating stream capacities for radioactive wastes. Studies on the Mohawk (*14*) using phosphorus-32 demonstrated the concentration of radioactive phosphorus by biota. In addition, certain hydraulic characteristics of the stream were revealed. Scandium-46 was used in tracing sewage effluent discharged into Santa Monica Bay (*15*). A study on the Ottawa River (Ohio) in which salt, fluorescein, and rubidium-86 were tried in flow measurements indicated that these tracer materials produced similar results (*3*).

Tritiated water, because of its chemical similarity to normal water, should be an ideal tracer for flow studies of this type. However, it has found limited application because of difficulties in measuring it. Tritium has been used successfully, nonetheless, in tracing flow through a model of the Savannah Tidal Estuary (*16*).

Ground Water

The cation exchange properties of soils are a principal deterrent in selecting effective tracers for ground-water movement. Although Fox (*17*) successfully employed rubidium-86, the soil studied was a porous, sandy type, atypical of most soils. Kaufman and Orlob (*18*) concluded that only anionic tracers, such as iodine-131, or non-ionic tracers are suitable for ground-water tracing. Chelation has been suggested as a means of converting radiocations to non-ionic form for use as ground-water tracers. The process has been demonstrated successfully in the laboratory (*19*).

Use of tritium as a ground-water tracer is being studied. Its concentration in ground water is also being used to determine the water's age (*20*).

Flow of Solids

Settling or scouring of solids from liquid media can frequently be measured directly. In some instances, however, information regarding the interchange of solids is desirable. For example, the movement of silt in the River Thames has been studied through use of sand particles tagged with scandium-46 (*6*).

Floc particles bearing radionuclides have been used to determine removals by filtration media. In one such study, the effective depth of penetration of floc particles in sand filters was observed by use of iodine-131 tracer (*21*). In another study, iron-55 and iron-59 were used to evaluate graphite, anthracite, and sand as filtration media (*22*).

Water Quality

Analytical procedures employing radioactive tracers have been developed for both chemical and bacteriological contaminants in water. In many instances these procedures have markedly increased the sensitivity of measurement and have simplified assay methods as well. Radioactive tracers have been used also to determine removal mechanisms and related factors in various treatment processes designed to improve water quality.

Chemical Assay

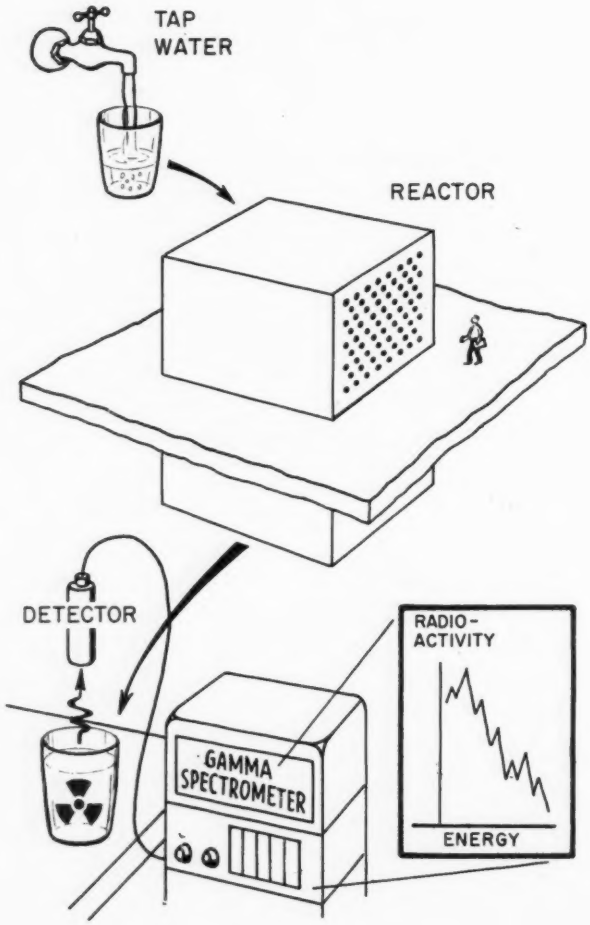
For chemical assay, two basic approaches have been explored: radiometric titration methods and neutron activation analysis.

Radiometric titration techniques using nuclide tracers to sensitize the end point have been specified for chloride and sulfate determinations. Many other applications have been suggested (*23*).

Activation analysis has been widely accepted in many fields for the determination of trace quantities of more than half the known elements (*24*). The technique is based on the fact that most elements when subjected to neutron bombardment give rise to radioactive species of the same element. The radiations emitted by these materials are characteristic of the particular element. Through study and measurement of emitted radiations, it is possible to determine the quantities of stable elements originally present in the sample.

The recent application of the neutron activation technique to the analysis of drinking water promises to broaden and extend knowledge of water quality (fig. 2). Typical elements readily determined in water by this procedure include chlorine, bromine, iodine, copper, arsenic, manganese, barium, strontium, and sodium. Concentrations in the range of 1 part in 10^9 are easily detected (*25*).

Figure 2. Chemical Assay: Neutron activation provides an analytical method for both qualitative and quantitative determination of stable elements.



Bacteriological Assay

Basic knowledge regarding the metabolism of various food essentials by organisms has been expanded in recent years as a result of tracer techniques. A development which shows promise in the field of water quality assay is a rapid technique for the presumptive coliform test. This technique is based on the metabolism of lactose labeled with carbon-14 to form radioactive carbon dioxide (*26*). This metabolite, indicating a presumptive test, can be detected in as short an incubation time as 15 minutes (fig. 3).

Water and Waste Processing

Corrosion and scale formation have concerned the sanitary engineer for many years. Today studies employing radioactive materials promise to help him gain a better understanding of these conditions. Studies employing calcium-45 have yielded information regarding the mechanism of scale formation (*27*).

The mechanism by which phenol is adsorbed and desorbed from activated carbon has been investigated by using phenol labeled with carbon-14 (*28*). The fate of a detergent subjected to activated sludge treatment was studied by use of detergent tagged with sulfur-35 (*29*). With phosphorus-32 tracer, the phosphate cycle, including biota uptake and circulation, has been studied in lake water (*30*).

Gamma radiation for disinfection of water or sewage is frequently mentioned. Use of waste fission products in treating the material has been suggested; also sterilization of sewage by using it as a reactor coolant (*31*). Studies have indicated that high exposure levels (about 1 million roentgens) are required for disinfection (*32,33*). Hence, the feasibility of such irradiation methods is doubtful because of

Figure 3. Bacteriological Assay: Radiotracers may provide a rapid and sensitive method for the presumptive coliform test.

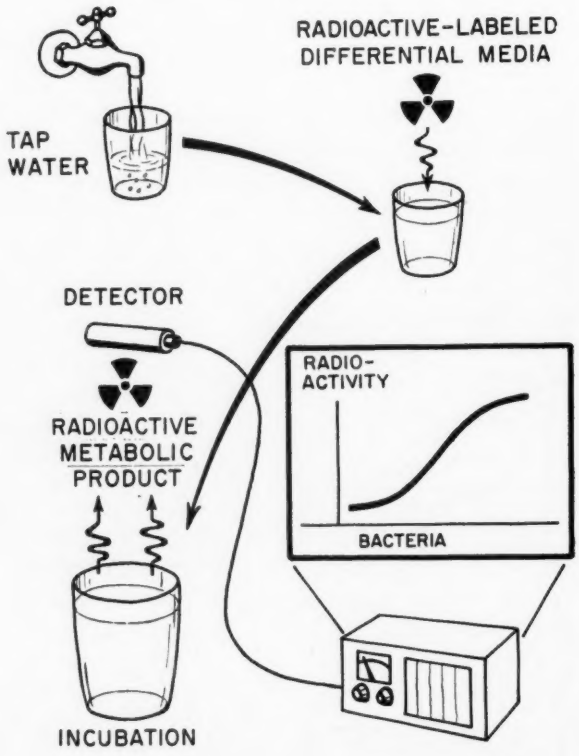
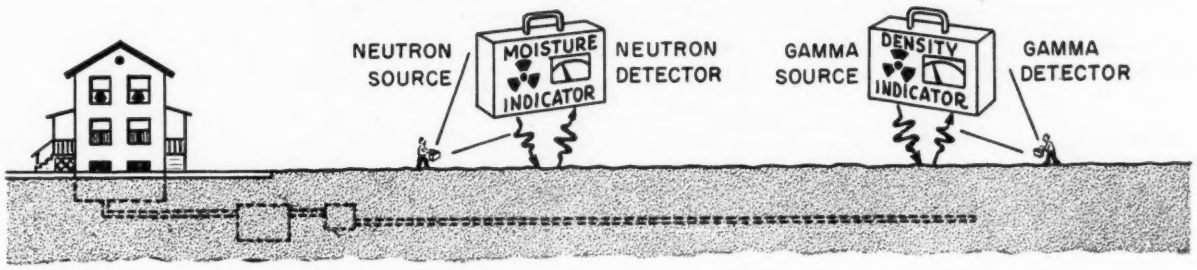


Figure 4. Soil Properties: Field measurements of soil moisture and density show promise for use in designing household sewage disposal systems.



safety considerations. The neutron activation problems associated with the latter proposal might be particularly troublesome.

Studies have been made on the transport of sewage sludge through a digestion tank using raw sludge labeled with radioactive phosphorus (*34*). Beneficial information has resulted, particularly with regard to methods for stirring, adding, and withdrawing sludge from such systems. Use of radiation to develop new strains of biota for better oxidation of sewage has been proposed. This suggestion is based on the known ability of radiation to produce genetic changes. Through such changes improved strains of biota might result.

Other Applications

Applications of radiation in sanitary engineering cover a wide variety of other subjects.

Hydrology

Accurate predictions of runoff from snow packs are readily accomplished through use of gamma sources (*35*). Attenuation of the radiation by the snow itself permits accurate determinations of its depth. For example, with a 40-millicurie cobalt-60 source, depths having a water equivalent up to 55 inches can be measured and the information automatically reported from remote locations by means of a telemetering system (*36*).

Soil Properties

Density and moisture content of soils are amenable to measurement by use of radiation, and such measurements can be made directly in the field. In early studies, soil density was determined by the degree of gamma ray attenuation (*37*). In more recent developments,

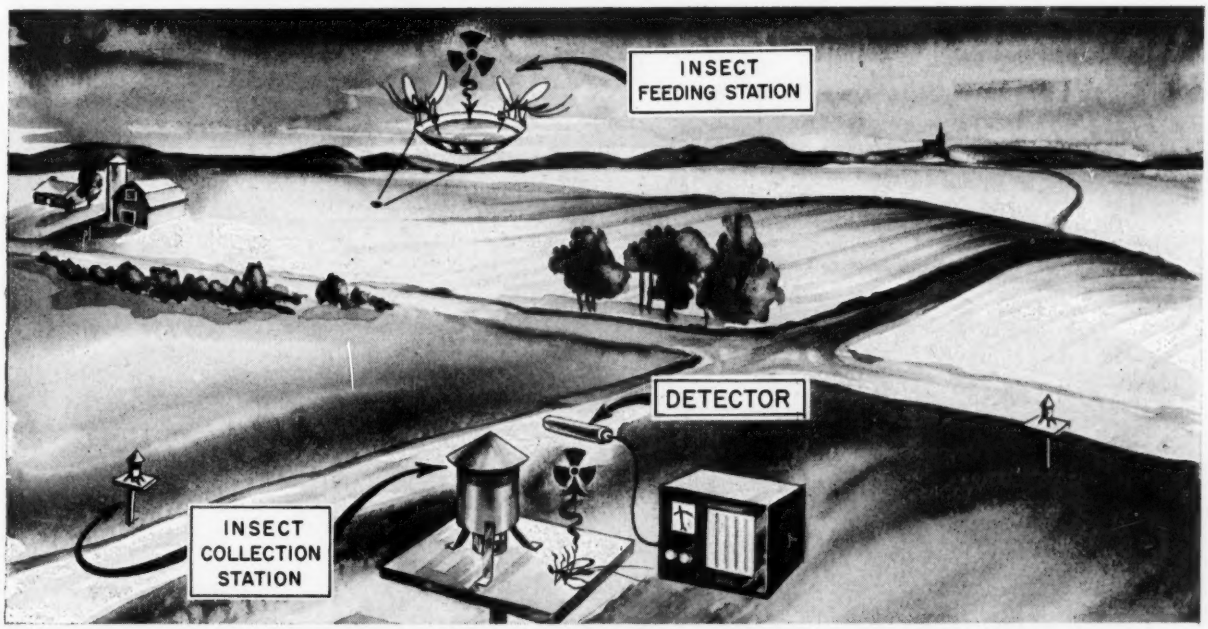


Figure 5. Insect Control: Feeding and migratory habits of insects are being studied with radiotracers.

density is measured by correlation with the amount of scattering of gamma radiation when a radiation source is placed in contact with the soil (*38*). Moisture-content measurements are based on the neutron-moderating properties of soils. A source of fast neutrons is used in conjunction with a slow neutron detector. For most soils, the number of slow neutrons detected is proportional to the hydrogen or water content (*12*). These techniques offer promise in establishing design criteria for rural sewage disposal systems (fig. 4).

Insect Control

Radionuclide tracers are providing information on the travel of insects, their feeding and parasitic habits, and other factors affecting disease transmission (fig. 5). As an example, the dispersal of mosquitoes and flies has been studied using phosphorous-32 and zirconium-95 tracers (*39*).

For control of certain insects, particularly the screwworm fly, gamma radiation is being used to sterilize the males and thereby interrupt the reproduction cycle (*12*). It is envisioned that within the next few years complete eradication of the screwworm fly in southeastern United States will be possible by this means.

Another approach to insect control is the use of gamma radiation to reduce insect infestation in packaged materials. Irradiation with cobalt-60 and fission products has been studied as a technique for ridding packaged foods of various species of beetles and flies (*40*). Exposures of about 65,000 roentgens are required to kill, 16,000 to 32,000 to inhibit reproduction. Irradiation has certain inherent advantages over chemical fumigation, particularly the ease of application and completeness of control (*40*).

Food Preservation

Research indicates that all types of food can be sterilized by radiation, regardless of the species or numbers of contaminating organisms. Certain side reactions, however, may make the food less wholesome, cause changes in taste or texture, or create toxic products (*41*).

Transmission of trichinosis through pork products is of particular public health importance. Studies of gamma irradiation of raw pork, with cobalt-60 or fission products, have shown that transmission of this disease can be prevented without producing detectable taste changes (*42*). Radiation exposure levels of about 20,000 roentgens are sufficient to inhibit the maturation of trichina larvae (*43*).

Food Sanitation

Cleansing abilities of detergents are being evaluated through use of radionuclide-tagged soils and bacteria. Methods for the preparation of the soils have been formulated (*44*). Among a variety of radionuclides tried, phosphorus-32 has proved good for tracing bacteria. Through such applications, the relationship of cleansing efficiency to type of utensil, surface conditions, and type of organism has been evaluated (*45*).

Air Pollution

Radionuclides have proved successful in providing data on the dispersion and dilution of air contaminants and the effectiveness of control measures. A unique method of using a radioactive gas to trace dust aerosols has been reported (*46*). If a radioactive gas, such as thoron, is added to a dust aerosol, the radioactive atoms of the decay products will be adsorbed by the dust particles. The resultant radioactivity of the aerosol may then be used to characterize the finest suspended matter. Dusts, so labeled, have provided information on filter efficiencies, the structure of filter media, and the mechanism of operation of sampling and control equipment.

Another application in the field of air pollution investigation is neutron activation. For example, the dispersal of nonradioactive antimony oxide from a stack was traced through irradiation of collected air samples in the reactor at the Oak Ridge National Laboratory (*47*). With this technique, as little as 3×10^{-9} gram of antimony per cubic foot can be detected. This is a sensitivity exceeding that of the best chemical method. It is also interesting to note that under the conditions of the experiment no radioactive material was released to the atmosphere.

Conclusion

Essentially every phase of sanitary engineering has benefited from nuclear technology, and the potentialities of the applications appear to

be endless. Hence, nuclear science is assisting substantially in attainment of the goal of sanitary engineering: the improvement of the public health, principally through the control of man's environment.

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Coordinator of International Affairs

A new position, Departmental Coordinator of International Affairs, has been established in the Department of Health, Education, and Welfare.

The new position will coordinate international activities related to health, education, vocational rehabilitation, social insurance, social welfare, and other areas within the Department and provide liaison with other Government departments and agencies having international concerns. The Department's operating agencies will continue to hold direct administrative responsibility for the international aspects of their programs.

Robert A. Kevan has been named to fill the new post. He served as special assistant to the chief medical director of the Veterans Administration and for 2 years was assistant chief of the Formosa field office of a management consultant firm before coming to the Department in March 1958 as assistant to the Assistant Secretary.

Effect of Natural Fluorides On Caries Incidence In Three Georgia Cities

FRED D. LEWIS, JR., D.D.S., and
ERNEST C. LEATHERWOOD, JR., D.M.D.

DENTAL HEALTH services of the Georgia Department of Public Health and of the Public Health Service in Region IV were requested by the dental society, chamber of commerce, and health department of Savannah, Ga., to make a detailed study of the prevalence of dental caries in the children of Savannah in relation to the fluoride content of its water supply. The natural fluoride content of Savannah's water supply was approximately one-half the concentration recommended by the State health department. The question was: How much additional reduction in the caries attack rate would be derived from the adjustment of this concentration to the approved range?

A dental survey was planned for Savannah and two geographically comparable communities having known concentrations of natural fluoride in their public water system. It was estimated that Savannah had from 0.3 ppm to about 0.5 ppm fluoride concentration. The Georgia cities of Macon and Moultrie were chosen as controls, for, according to the water control laboratory of the State health department, the natural fluoride content of Macon's water supply was 0.11 ppm and Moultrie's was about 0.75 ppm. These concentrations were determined from water samples collected during a 3-year period, 1954–56. (Macon obtains its water from the Ocmulgee River, Savannah, from 11 deep wells and the Savannah River, and Moultrie from 3 deep wells.) Forty samples tested for Macon showed a range of 0.0 to 0.5 ppm fluoride in the water supply. Moultrie's range was 0.3 to 1.4 ppm in 52 water samples tested.

Macon would serve as the baseline while Moultrie would indicate the caries attack rates present at the lowest fluoride level recommended by the State health department. The optimum fluoride concentration as determined by the formula relating fluid intake to mean maximum temperature (*1*) approximates the natural fluoride concentration present in the Moultrie water system. The mean maximum temperature according to the U. S. Weather Bureau station in Atlanta and Athens, Ga., was 76.6° F. for Savannah, 77.6° F. for Macon, and 80° F. for Moultrie, over a period of 82, 57, and 24 years respectively.

Over the years, Savannah has continually expanded, outreaching and overtaxing the public water system. To meet the increased demands, new wells were added directly to the water system at the point of greatest need. Today there are 11 independent deep wells and a surface supply with 2 separate pumps. Between March and October 1956, 138 samples from all water sources showed a range in fluoride of 0.0 to 0.8 ppm. The average fluoride concentration for each well ranged from approximately 0.31 ppm to 0.53 ppm, while the surface supply averaged about 0.06 ppm. This resulted in an overall numerical average of about 0.37 ppm fluoride concentration (table 1). Since records have been kept only in recent years on the fluoride concentration in the water system, the assumption was that the samples taken in 1956 would be indicative of the fluoride concentration in the water system for the entire life of the children examined.

The pumpage rate of each well fluctuated, depending upon the needs of the system, and since there was no common reservoir, there was no distribution constant. During 1956, the pumpage rate of individual wells varied from approximately 28 million to 1.4 billion gallons of water, and the surface source supplied about 35 million gallons. The inconstant pumpage rate and variation in the fluoride concentration necessitated the determination of a weighted average fluoride concentration in the water system for the year. By dividing the total

Dr. Lewis is regional dental consultant, dental health service, Georgia Department of Public Health. Dr. Leatherwood is senior assistant dental surgeon, Public Health Service, Region IV.

Table 1. Average fluoride concentration in water supply, Savannah, Ga., 1956

Well No.	Gallons of water pumped	Number test samples	Fluoride range (ppm)	Average fluoride concentration (ppm)
1	220, 794, 332	11	0. 4–0. 8	0. 53
2	317, 192, 899	11	. 3– . 7	. 47
3	28, 474, 120	4	. 3– . 5	. 42
4	1, 059, 072, 217	11	. 3– . 5	. 45
5	1, 389, 495, 413	14	. 3– . 5	. 34
6	407, 671, 408	14	. 2– . 4	. 31
7	404, 160, 621	10	. 2– . 7	. 35
8	1, 112, 522, 738	9	. 3– . 4	. 32
9	788, 729, 221	13	. 3– . 5	. 39
10	596, 650, 207	10	. 3– . 5	. 38
11	179, 933, 182	7	. 3– . 5	. 41
12 and 13 [1]	37, 398, 000	24	. 0– . 3	. 06
Total	6, 542, 094, 358	138	. 0– . 8	. 37

[1] Surface water supply.

parts fluoride from each well by the total number of gallons pumped, a concentration of 0.38 ppm was calculated.

Materials and Methods

A survey technique to obtain the required data was decided upon early in the planning stage (*2*). Participation in the dental survey was limited to white school children 6–15 years of age who were continuous residents, had used only the public water supply since birth, and had parental consent.

Careful dental examinations were conducted by two dentists, Hubert H. Martin from the Georgia Department of Public Health and Ernest C. Leatherwood from Region IV, Public Health Service. A tooth surface was considered carious if the end of the dental explorer penetrated the soft, yielding tooth structure; if, in the case of pits and fissures, the explorer caught, supported its own weight, and met resistance when it was withdrawn; or if the surface had a carious lesion which was clinically obvious. The observations of the two examining dentists were recorded in code on the patient's chart (*3*) along with the following data:

1. Number of teeth erupted.
2. Number of permanent teeth extracted and

Table 2. Percentage of caries-free permanent teeth in children, by age, in Macon, Savannah, and Moultrie, Ga., 1956–57

Age (years)	Number of children examined			Percent children caries-free		
	Macon	Savannah	Moultrie	Macon	Savannah	Moultrie
6	371	554	71	48. 2	49. 3	76. 1
7	419	622	80	40. 3	42. 1	58. 8
8	413	652	61	25. 7	29. 4	50. 8
9	442	638	64	18. 8	23. 7	40. 6
10	402	478	64	10. 0	16. 9	46. 9
11	280	440	40	10. 0	13. 9	27. 5
12	300	417	37	6. 3	9. 4	32. 4
13	432	374	47	5. 1	9. 6	27. 7
14	450	397	52	3. 1	5. 5	21. 2
15	381	299	24	1. 8	6. 0	16. 7
Total	3, 890	4, 871	540	17. 1	23. 3	44. 3

reason for extractions: orthodontic purposes, trauma, or otherwise.

3. Number of primary and permanent teeth needing extraction.

4. Number of unfilled carious teeth and number of surfaces involved.

5. Number of filled teeth and number of surfaces restored.

Findings

A total of 9,301 school children participated in this dental survey, 3,890 from Macon, 4,871 from Savannah, and 540 from Moultrie. Even though the number of children in Moultrie was relatively small, when the data from all three communities on caries-free children and on decayed, missing, and filled (DMF) teeth were subjected to the chi-square test, they were found to be statistically significant (*4*).

Table 2 shows the number of children examined as well as the percentage with caries-free permanent teeth. The total for all ages shows that for permanent teeth, 17.1 percent of the children in Macon are caries-free, while 23.3 percent of Savannah's children are caries-free, and 44.3 percent of Moultrie's children are caries-free.

The percentage difference in the total DMF rates, as shown in the last three columns of table 3, indicates that the children of Savannah have 35.6 percent fewer caries than those of Macon. Moultrie shows 60.8 percent less dental decay than Macon and 39.1 percent less than Savannah.

The difference in the decayed, missing, or filled rate per child at each age in the three cities is shown in the chart.

Decayed, missing, or filled permanent teeth per child by age, Macon, Savannah, and Moultrie, Ga., 1956–57.

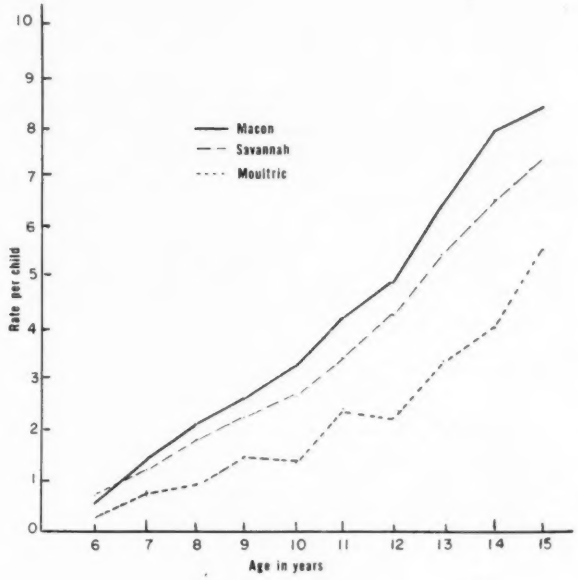

Table 3. Decayed, missing, or filled (DMF) permanent teeth, DMF rate per child, and percentage difference in DMF rate per child, by age, Macon, Savannah, and Moultrie, Ga., 1956–57

Age (years)	Number permanent teeth DMF [1]			DMF rate per child			Percent difference in DMF rate		
	Macon	Savannah	Moultrie	Macon	Savannah	Moultrie	Savannah over Macon	Moultrie over Savannah	Moultrie over Macon
6	197	365	16	0.53	0.66	0.23	+24.5	−65.2	−56.6
7	581	733	70	1.39	1.18	.88	−15.1	−25.4	−36.7
8	837	1,125	59	2.03	1.73	.97	−14.8	−43.9	−52.2
9	1,127	1,356	91	2.55	2.13	1.42	−16.5	−33.3	−44.3
10	1,264	1,236	83	3.14	2.59	1.30	−17.5	−49.8	−58.6
11	1,158	1,440	91	4.14	3.27	2.28	−21.0	−30.3	−44.9
12	1,451	1,733	80	4.84	4.16	2.16	−14.0	−48.1	−55.4
13	2,663	1,981	154	6.16	5.30	3.28	−14.0	−38.1	−46.8
14	3,597	2,464	208	7.99	6.21	4.00	−22.3	−35.6	−49.9
15	3,182	2,149	131	8.35	7.19	5.46	−13.9	−24.1	−34.6
Total	16,057	14,582	983	4.64	2.99	1.82	−35.6	−39.1	−60.8

[1] Exclusive of third molars.

Table 4. Number of primary teeth decayed or filled (df) and df rate for ages 6–11 years, Macon, Savannah, and Moultrie, Ga., 1956–57

Age (years)	Number of children examined			Number of df primary teeth			df rate		
	Macon	Savannah	Moultrie	Macon	Savannah	Moultrie	Macon	Savannah	Moultrie
6	371	554	71	1, 770	2, 253	260	4. 77	4. 07	3. 66
7	419	622	80	2, 004	2, 455	299	4. 78	3. 95	3. 74
8	413	652	61	1, 890	2, 437	214	4. 58	3. 74	3. 51
9	442	638	64	1, 587	1, 941	157	3. 59	3. 04	2. 45
10	402	478	64	1, 029	960	116	2. 56	2. 01	1. 81
11	280	440	40	301	486	23	1. 08	1. 10	0. 58
Total	2, 327	3, 384	380	8, 581	10, 532	1, 069	3. 69	3. 11	2. 81

An analysis of the decayed-filled (df) rate in primary teeth is presented for these cities in table 4. Moultrie has the lowest df rate for the children examined.

Discussion

From the findings, it is obvious that an inverse relationship exists between the caries attack rates and the concentration of fluorides in the water system of these three communities. Approximately one-fourth of the permanent teeth of the children examined in Macon were decayed, missing, or filled, one-fifth in Savannah, and one-ninth in Moultrie.

The DMF rates of the 12–14-year-old groups in Macon, Savannah, and Moultrie can be plotted upon Dean's graph of dental caries experience in 21 cities (*5*). The pattern is similar even though these rates occur in cities with a warm climate.

The DMF percentage difference between Savannah and Moultrie demonstrates decisively the additional protection against dental decay that could be achieved in Savannah by increasing the fluoride concentration of the water system from 0.38 ppm to at least 0.75 ppm (but no more than 1.0 ppm).

Conclusion

Savannah, with a natural fluoride content of about 0.38 ppm in the water system, is providing its children with 35.6 percent protection against dental decay. An additional 39.1 percent reduction in caries would be expected if Savannah were to increase the fluoride concentration to equal Moultrie's (0.75 ppm). Macon, with only a trace of fluoride in its water system, would expect to reduce dental caries in its children by at least 60.8 percent with adequate fluoridation.

Summary

A dental survey of 9,301 continuously resident, white school children between the ages of 6 and 15 years was conducted in the cities of Macon, Savannah, and Moultrie, Ga., in order to determine the effect of different concentrations of natural fluoride in the water systems upon the rate of dental decay.

The natural fluoride concentration was approximately 0.11 ppm for Macon, 0.38 ppm for Savannah, and 0.75 ppm for Moultrie. The mean maximum annual temperature for these cities was 77.6° F., 76.6° F., and 80.0° F. respectively.

On a percentage basis, Moultrie had about twice as many caries-free children as Savannah and more than two and one-half times as many as Macon.

The decayed, missing, or filled (DMF) rate for permanent teeth per child was 4.64 in Macon, 2.99 in Savannah, and 1.82 in Moultrie.

Moultrie's DMF rate was 60.8 percent lower than Macon's and 39.1 percent lower than Savannah's; Savannah's was 35.6 percent lower than Macon's.

The decayed-filled rates for primary teeth were slightly lower in Moultrie than in the other two communities.

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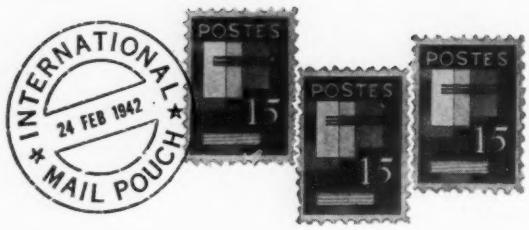
Epidemiological Note

Smallpox

The recent occurrence of smallpox in Germany, which was introduced by a traveler from India, prompted the application of rigid requirements for vaccination of persons entering the United States from Western Europe. There was need for making the requirement apply to persons traveling from more areas than the one where the index case eventually was hospitalized. He had symptoms of the disease while traveling by plane from the Far East, and fellow travelers destined for various parts of Europe were exposed to infection. He also stopped in Switzerland before going to Germany. Secondary cases and one death have been reported, all of them from the area of Germany where the index case was found.

Failure to recognize the possibility of smallpox in persons traveling from infected areas has been followed by several localized outbreaks in Europe in the past decade. In each instance, it has been necessary to apply rigid vaccination requirements for travelers from these epidemic areas before entrance into the United States.

The United States has not been immune to the introduction of the infection from other countries. In one instance in 1946, a soldier returning from Japan developed smallpox en route to Seattle. In spite of isolation, the disease spread, and there was a final total of 28 cases with 8 deaths. In 1947 a man traveling from Mexico City by bus presumably developed first symptoms of the infection en route to New York City. This case was not recognized as smallpox except in retrospect. In this outbreak, there were 9 cases with 2 deaths including the first case. These two outbreaks show very clearly what may happen if the infection is introduced and why rigid requirements for vaccination of persons subject to possible exposure are justified. Vaccination is required for protection not only of the traveler but also of the public.—Dr. Carl C. Dauer, *medical adviser, National Office of Vital Statistics, Public Health Service.*



Water Hunter

Experience in ground water exploration sometimes pays off. After 2 months of exploratory work, contract technicians reported that no water was available for a certain small town in Brazil. An experienced engineer and a crew from Serviço Especial Saúde Pública located a 4-meter stratum of good, water-bearing sand 10 hours after they arrived in the area.

—E. Ross Jenney, M.D., *chief, Health and Sanitation Division, U. S. Operations Mission, Brazil.*

26 Million Tails

With all the returns counted in its nationwide campaign, the Ministry of Health and Social Welfare of the Republic of Korea has collected 26,994,758 rat tails. The 2-month eradication effort was to combat foci of typhoid fever. However, a second wave of the disease hit Pusan, where 97 cases including 8 deaths were reported, 3 months after the campaign ended.

—Alfred S. Lazarus, Ph.D., *chief public health adviser, U. S. Operations Mission, Korea.*

Teamwork

International teamwork helped Thailand combat a cholera epidemic in May and June 1958. Following news of the outbreak, 500,000 cc. of vaccine from the Serum and Vaccine Laboratories of the Philippines Government and an equal amount from reserve supplies in the United States were flown to Thailand. UNICEF sent equipment to produce the vaccine, and a United States Navy medical research team from Taiwan went to Bangkok to give bacteriological and epidemiological assistance.

The first cases were reported in Bangkok May 23, and the outbreak reached a peak 15 days later when 230 cases were reported. Twenty provinces reported cholera, and by the end of June, Thailand had nearly 6,000 cases with 868 deaths. The fatality rate, at first over 15 percent, dropped below 10 percent as treatment facilities improved and intensive vaccination and health information campaigns gained momentum.

After a few cases occurred in neighboring Cambodia, mass inoculation began and preventive measures were publicized. Part of the vaccine used in Cambodia was produced at the Pasteur Institute in Phnom Penh, using equipment provided several years ago by the Agriculture Division of the U. S. Overseas Mission.

—Andrew P. Haynal, M.D., *chief, Public Health Division, U. S. Operations Mission, Thailand, and* Carleton B. White, M.D., *chief, Public Health Division, U. S. Operations Mission, Cambodia.*

Droit du Seigneur

In 1954, during one of my visits to the village training institute at Rahimyar Khan, West Pakistan, I showed a motion picture on constructing an earth privy. About 2 weeks later when I returned, I was met at the train by the institute's principal, several instructors, and many of the trainees. Their salaams were hasty and they seemed excited as they escorted me to a jeep and whisked me off to the institute, instead of to the resthouse, the usual first stop to unpack, bathe, and breakfast.

At the institute, as the trainees lined up, did a military right face and marched forward, the principal indicated I was to follow. The line of march halted 75 yards away in a corner of the campus. There, guided by the motion picture, the trainees had constructed an earth privy, complete with superstructure, the first ever built at the institute, and probably the first in the state of Bahawalpur.

A red ribbon was strung across the entrance, and the trainees indicated that I, their "uncle," a term young Pakistanis use to show respect to an older man, was to officiate at the opening. The students cheered and camera shutters clicked while I cut the ribbon. I repeated the act so that all the photographers could get their pictures.

I complimented the trainees and turned to go, but excited voices told me my ceremonial duties were not ended. Their American "uncle" was also to be the structure's first guest.

—Alexander A. Robertson, *health and sanitation adviser, U. S. Operations Mission, Thailand, formerly a member of U. S. Operations Mission, Pakistan.*

Disposal of Industrial Wastes by Irrigation

F. H. SCHRAUFNAGEL

RESPONSIBLE officials are interested in a waste disposal or treatment facility that is economical to build and operate, requires little attention, and still does a satisfactory job. Disposal by irrigation meets these specifications for some industrial wastes, and it has attracted a great deal of interest recently. Irrigation as a means of disposal is not new; this method was used extensively on sewage farms beginning in the 1860's and 1870's.

The two principal methods of using irrigation to dispose of waste water on the land are ridge and furrow irrigation and spray irrigation. In the ridge and furrow method, wastes are disposed of in furrowed plots. Early systems used a single or a few furrows, and the wastes were directed manually to another furrow when one was full, a technique that can also be used with contour furrows on sloping land. On relatively flat land, two or more plots are usually developed.

Wastes are discharged to a main or header ditch, which may be in the center of the plot or at the side, and then flow into the furrows which are nearly level but at a higher elevation. Furrows are 3 to 15 feet apart, 1 to 3 feet deep, and 1 to 3 feet wide. When wastes in one section build up to about 6 inches from the ridge tops, a control gate can be set for overflow into another area. Control gates can also be used to take an area out of service for maintenance or to rest the land.

Compared with spray irrigation, ridge and furrow systems have a higher original cost and a lower operating cost, and can handle higher volumetric loadings. They have no problems caused by freezing during cold weather. But they are more likely to develop into a nuisance and may require additional land to get farther away from factories, dwellings, or public roads. Because land irrigated in this manner is difficult to crop, grasses are frequently left uncut, but noxious weeds must be destroyed.

Disposal by spray irrigation is a recent development in this country. The first installation of this type appears to have started operating in 1947. Only a few had been installed prior to 1950, but since that time use of this method has mushroomed. Wastes are sprayed onto the land, usually through revolving nozzles. Lightweight metal or plastic pipe is frequently used to convey wastes from a wet well or holding pit to the disposal field. Pipe sections can be moved easily to change spray areas, and, in some cases, extra piping and a valving arrangement can divert wastes to different locations.

The land does not require special preparation and moderate slopes can be tolerated. Woodland, brush areas, pastures, and cropland have been used successfully for waste disposal. Generally, it has been easier to obtain land for spray irrigation than for ridge and furrow systems. In a few cases, industry has been given use of land in exchange for the wastes and their possible fertilizer and moisture

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value. Spray-irrigated grasslands are sometimes cropped. The biggest disadvantage of spray irrigation is the difficulty of operation during freezing weather. Some factories which dispose of wastes daily use spray irrigation during warm weather and ridge and furrow or other methods in the colder months.

Dairy Wastes

Dairies, many of them in rural areas and small villages close to the milk supply, are the source of the industrial waste most prevalent in Wisconsin. In June 1956, the State had a total of 1,625 factories engaged in the processing of milk and allied products from a yearly farm production of 16 billion pounds.

These factories create a variety of wastes, depending on the type of operations, the inclusion of concentrated wastes, and whether or not all or part of their cooling water is used in irrigation. The wastes may have a biochemical oxygen demand (BOD) ranging from less than 200 ppm for receiving station wastes to 15,000 ppm for a cheese factory discharging excess whey along with wash water wastes.

In 1954 the Mindoro Cooperative Creamery in western Wisconsin began operation of a ridge and furrow system with pumping facilities. Its irrigation area of about 3 acres is divided into 3 plots which are underlaid with 2 lines of drain tile. Cost of the completed system, including $2,000 for land and $2,000 for pumping facilities, was approximately $8,000. This system accomplished a high degree of treatment; the BOD increase in the receiving stream is only 0.1 ppm, compared with 41.6 and 26.0 ppm before ridge and furrow facilities were installed.

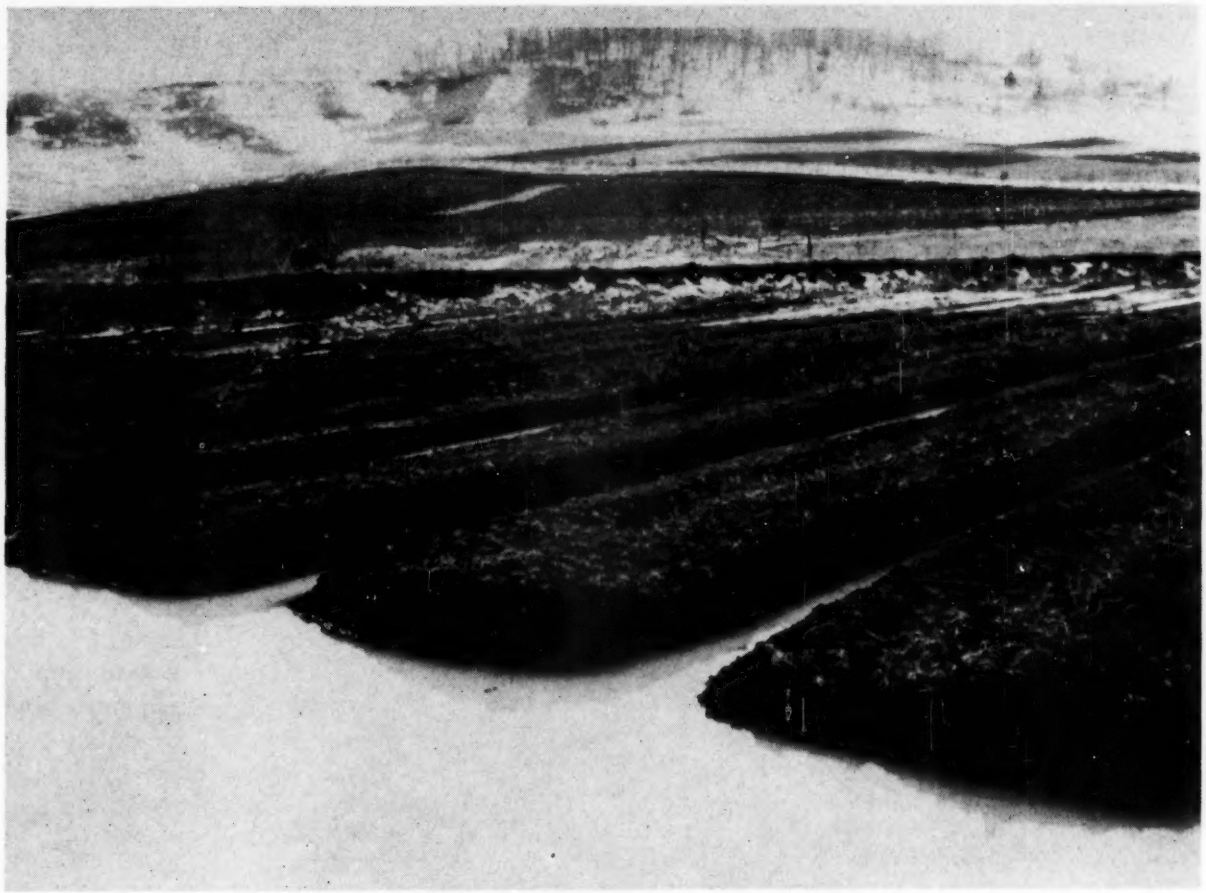
About 20 other Wisconsin milk plants, mainly creameries, now have ridge and furrow systems. Minimum rates of waste disposal vary from less than 3,000 to more than 32,000 gallons per acre per day (gpad). Original costs ranged from $300, for a small factory where 3 furrows were dug and gravity flow was used, to approximately $25,000, for a large plant where the disposal field required extensive leveling.

A nuisance is more likely to develop in warm weather when a ridge and furrow system is used for wastes with high BOD concentration; therefore, cheese factories have been encouraged to adopt spray irrigation. Occasional excess whey apparently can be handled without difficulty, but operators are cautioned about overloading systems with whey. Milk wastes have little gross solids in them, and elaborate screening is not required. The systems usually need a small basket screen or bucket with holes under the holding tank influent line to collect bits of curd, steel wool, brush bristles, and matchsticks, thus keeping them out of the nozzles. Scum and sludge will develop and accumulate in the holding tank, but this can be prevented by tapping off a $\frac{3}{8}$-inch or $\frac{1}{2}$-inch line beyond the pump, and returning some flow to the tank to agitate its contents.

Wisconsin now has about 30 milk plants using spray irrigation. Original cost, excluding land, ranged from $300, for a small factory whose operators used old equipment and did most of the construction work, to $5,000. Some disposal rates average only 2,000 gpad in extremely heavy soils while in favorable soils, rates of 10,000 to 15,000 gpad are sometimes achieved.

Six plants, mostly cheese factories in southern Wisconsin, continue spray irrigation during the winter. To prevent freezing in their systems these plants use a holding tank large enough to store 1 day's waste, a well-insulated pump and motor, and a heat lamp. The pump is started around noon, generally the warmest time of the day, and runs continuously for about 2 hours until the end of the work day. Pipes are supported on posts and slope back to the wet well. An icecap up to 2 feet thick may develop around the sprays. Most of the vegetation under the ice is permanently killed off, and these spots must be reseeded in the spring.

Waste temperatures of 90° to 100° F., an advantage for winter spraying, have been found at some of the cheese plants. A whey processing plant whose wastes at 135° F. killed vegetation solved this difficulty by extending the discharge to 10 feet above the ground and using a finer spray nozzle. Whey condensate at one plant caused corrosion of the aluminum pipe, which was replaced with copper tubing.



Ridge and furrow irrigation system serving a milk plant. Furrows lead away from the main, or header, ditch in the foreground.

Spray irrigation during the warmer months has vastly improved conditions around some milk plants where wastes previously were a nuisance. One operator felt the change was worth $1,500 to him. In small communities near a resort area or a summer military camp where a milk plant contributes a significant part of the normal municipal waste, it may be easier and cheaper to irrigate the milk wastes than to enlarge sewerage facilities for the larger summer population.

Vegetable Processing Wastes

A 1913 report by the Water Survey of Illinois, mentioned in a 1939 bulletin, Methods of Treating Cannery Wastes (*1*), indicates that irrigation of pea and corn wastes in a large field gave best results. At the 1947 Purdue Industrial Waste Conference, Bolton (*2*) discussed Iowa canning plants which had started using ridge and furrow disposal 13 years earlier. In 1934 Iowa had 10 such installations for

The milk plant's system, photographed from the same point, after grass became established.

disposal of cannery wastes. He described the operations at the Hampton and Waverly plants in detail, since they had been functioning for several years. The Hampton cannery had a BOD loading of about one-ninth that of Waverly's, or 230 pounds of BOD per acre per day compared with 2,030 pounds of BOD per acre per day, although volumetric loadings for both averaged about 50,000 gpad.

Monson (*3*) reported that the Green Giant factory at Watertown, Minn., disposed of an average of 4.3 inches per day, or 116,000 gpad, on a ridge and furrow field. Generally, application rates for such systems range from about 5,000 to more than 100,000 gpad.

Canning operations are usually conducted during the summer when infiltration and evapotranspiration are highest. To my knowledge, no canneries in Wisconsin have used ridge and furrow irrigation exclusively for waste water disposal. However, in 1954 the California Packing Co. at Arlington used ridge and furrow for temporary disposal of wastes when its lagoon became full, and several pea viner stations have handled their stack juices by this method.

Spray irrigation of wastes from canning plants has become popular. There were no such installations in Wisconsin until 1951, when 11 were installed; by 1955, there were 40, representing 30 percent of the State's canning plants. The results, on the whole, have been gratifying, and many chronic pollution situations have been eliminated. The factories are requested to provide duplicate or standby pumping facilities, have thorough screening, and operate the system without ponding or runoff. When these conditions are met at an approved site, there is little danger of pollution or a nuisance.

Poultry and Tannery Wastes

A poultry processing establishment of Vallo-Will Farms, Inc., near Lake Geneva, Wis., treated its wastes, approximately 120,000 gpd with 220 pounds of BOD, in a high-rate trickling filter which accomplished an 80 percent BOD removal. This treatment was inadequate for the small receiving stream, and complaints were frequent. The effluent was chlorinated in 1954, and spray irrigation was started during the nonfreezing months. These measures eliminated discharge to the stream and also most of the complaints.

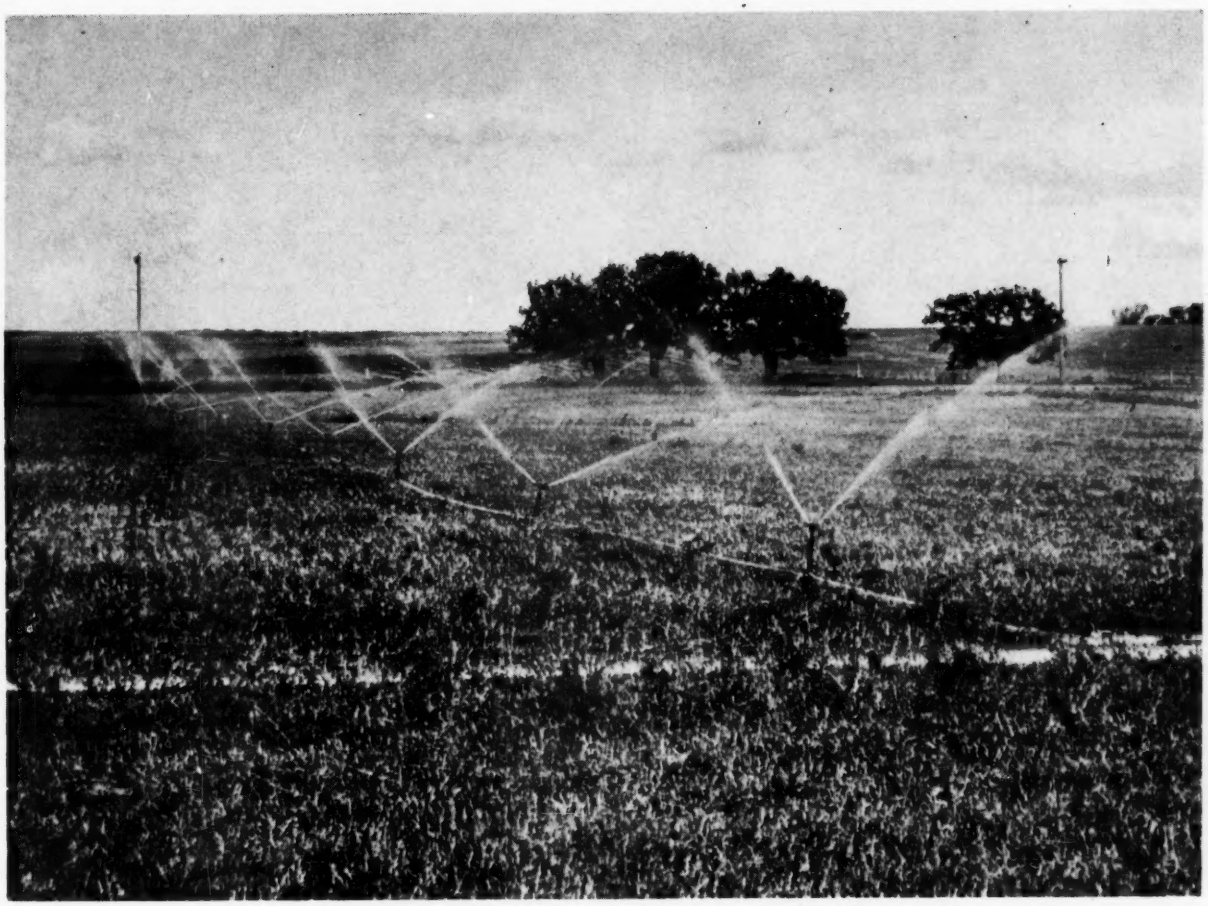
A ridge and furrow system was installed in the summer of 1957 when Edward Alf and Son of Endeavor, Wis., began operating a chicken processing plant. Two adjoining plots with a combined area of 1.05 acres and underdrained by two lines of 6-inch drain tiles were used. A "sparkling" effluent was noticed upon occasional observation, although wastes in the ditches and furrows are quite red. As yet, a detailed survey of the system has not been conducted. However, the waste volume amounts to an estimated 60,000 gpd on the 4 days a week the plant operates. A single grab sample from the drain tile in November 1957 had a BOD of 5.5 ppm. Solids, particularly feathers, are beginning to accumulate and improved screening is needed. An additional area of sandy soil is available for expansion.

A tanning plant which uses vegetable dyes in Pennsylvania spray irrigates wastes during critical stream periods from mid-May to late November (*4*). Wastes amount to 425,000 gpd and have a BOD of 2,300 ppm associated with a total solids concentration of 10,550 ppm. A 1,200-gpm pump, powered by a 150-hp diesel engine, applies the screened raw wastes to the land over a 6- to 7-hour period. Fifteen acres of land, whose soil consists of about 4 feet of sand over gravel, is used for disposal. Grasses were killed off originally, but in areas which are not sprayed for a time, vegetation grows profusely. A sludge layer accumulates and the plot is disk-harrowed every 3 weeks. Apparently no odor has been associated with spray irrigation of these wastes.

Pulp Wastes

Several Wisconsin pulping mills have experimented with and used irrigation to dispose of spent sulfite liquor. Approximately a ton of solids is dissolved from the wood for each ton of pulp produced. A 100-ton mill produces 200,000 gallons per day of this liquor, which has a BOD of 28,000 to 40,000 mg. per liter.

Studies of soil filtration were conducted by



Spray irrigation system in operation. Revolving nozzles are in a line perpendicular to the main line which crosses the foreground.

the Sulphite Pulp Manufacturers' Research League and reported by Wisniewski and associates (*5*). Ten-foot columns of mixtures of various media were used for experimental purposes, and different filtration rates were applied. Generally, BOD removal varied with the loading rates from a high of 95 percent, when 0.18 pound of solids was applied daily per square yard, to a low of 10 percent, with 12.3 pounds of solids. A field trial was made at a spray irrigation system, and removals of 40 percent were experienced with mean temperatures above freezing. During very cold weather the removal dropped almost to zero. In warm spring weather the BOD removal returned to about 30 percent.

In their report, the authors suggested consideration of the following principles of design and operation: (*a*) the effectiveness of microbiological reactions of the soil is greatly reduced if loadings of unstabilized organic matter exceed the rate of complete reaction; (*b*) the amount of water fed to the soil must be so controlled as to avoid sustained periods of flooding and the anaerobic conditions which result from flooding; and (*c*) geologic conditions must be such as to avoid the possibility of contamination of ground water supplies.

The Flambeau Paper Co. at Park Falls began using the irrigation method of disposal for some of its wastes in 1954. During critical stream conditions spent sulfite liquor is hauled out to a 40-acre disposal area by truck. The trucks dump along the road, constructed on a ridge in the area, which is wooded and has rock outcroppings. A bulldozer is used to construct absorption ditches. An aerial survey showed that about 40 percent of the trees were killed.

This pulp mill also spray irrigates some of its wastes on a 2-acre island which has a bark and

sawdust fill. The system has been able to apply the wastes satisfactorily through the winter but with a marked reduction in effectiveness.

The Kimberly-Clark mill at Niagara disposes of up to 250,000 gpd of spent sulfite liquor to a plot of sandy soil over rock. A pump, mounted on a trailer, is towed behind a truck and fogs the wastes out to a distance of 40 feet along each side of the road at a rate of less than three-fourths of a pound of solids per square yard. Four miles of road have been constructed to carry out the disposal of wastes in this manner.

Irrigation treatment of pulping wastes is poor compared with the treatment of wastes from food processing industries, and there is also danger of the sulfite liquor concentrating in underground pockets and polluting ground water supplies for extended periods. For these reasons irrigation of pulp wastes is considered only a temporary means of disposal.

Meat Packing Wastes

Oscar Mayer and Co., Madison, Wis., began experimenting with irrigation disposal of wastes in 1951 and started field disposal in 1953. Wastes are pretreated to remove grit, paunch manure, and grease, then subjected to flocculation and sedimentation. Secondary treatment, accomplished through trickling filters and sedimentation, is provided before discharge either to the Madison Metropolitan Sewerage District or to the irrigation fields.

The plant has 200 acres of land available for irrigation. In 1954, 17 percent of its wastes were disposed of by irrigation, with an application rate during the irrigation period of 10,000 gpad. The largest daily waste quantity that has been irrigated is 2,900,000 gallons. Quantities may vary considerably from day to day depending on such factors as rainfall and cropping. Wastes were spray irrigated until 2 years ago when the practice was discontinued because of complaints about odor by residents of an area near the disposal field. But it was not shown that the complaints were justified. Since that time, disposal on land has been mostly by flood irrigation. Mosquitoes caused the most trouble in 1957, and the best method of control was to dry out the various disposal areas at least every 6 days. Diking and careful operation are required so that wastes do not overflow.

Because wastes containing nutrients for algae must be kept out of the Madison lakes, irrigation is carried on only during the growing season, from mid-April to early November, when vegetation utilizes the fertilizer constituents of the wastes. The high sodium concentration of the wastes, about three times the maximum acceptable for irrigation, may eventually cause a soil problem if this concentration is not reduced.

The purposes of the plant's system are to reduce the sewer service charges and to demonstrate the use of a waste effluent for land irrigation. Because the campus of the University of Wisconsin in Madison is nearby, the project has received close study from its inception, and information about it has been published (*7*). Undoubtedly further findings will also be made available.

Evapotranspiration

What happens to an irrigated waste? Part is evaporated, some may be transpired, and the remainder is filtered away into the ground. A relatively small amount of mineral matter is used by the vegetation, but only water is transpired and evaporated so that the soil solution will contain higher quantities of solids than were present in the original waste water. The rate of evaporation of the liquid depends on temperature, humidity, and the area exposed, while the rate of transpiration depends mainly on leaf area, humidity at plant level, amount of solar energy, and available moisture. Under field conditions it is difficult to consider separately the water consumed by evaporation and that by transpiration, and the two are frequently lumped together as evapotranspiration, or consumptive use. The maximum consumptive rate for water is about 0.3 inch per day, or slightly more than 8,000 gpad during the hot, dry months. This rate is affected little by the type of forage crop. Normal evapotranspiration is 3,500 to 7,000 gpad.

Vegetation, by transmitting water and keeping the soil loose, is important to the success of a disposal system. Reed canary is probably by far the grass best suited for ridge and furrow irrigation plots in Wisconsin. It is a permanent grass and a heavy producer, has a substantial root structure, and endures water and ice sheet coverage very well. A seeding rate of

8 to 10 pounds per acre with the seed not covered too deeply is recommended. Brome grass and Kentucky bluegrass are probably next best suited, but they do not endure water and ice coverage as well. Some systems have developed good growths by seeding a mixture of these grasses. Trees and brush also do a good job of water transmission at some locations.

Pulp and tannery wastes from some plants have killed the vegetation originally present. The pH, temperature, or waste constituents may not have been suitable. Also, aeration in the root zone is considered essential for most vegetation. Hydrogen sulfide and nitrites are toxic to plant roots, and these compounds can be formed by waste decomposition when sufficient oxygen is not available. Occasional flooding can be tolerated, and flooding can be more frequent when plant life is dormant.

Opinions and findings as to what constitutes a suitable irrigation water vary greatly. Soil, drainage, crops, and climate are among the determining factors. Sandy and gravelly soils that are well drained can tolerate much higher concentrations than clay and poorly drained soils. Irrigation water is considered for total salts and the ionic concentration as shown by the water's specific conductivity; quantity of sodium and its ratio to other cations; amount of bicarbonate; and concentrations of boron, chloride, and sulfate.

Infiltration

Excluding the runoff, excess moisture can only percolate or infiltrate the soil at some periods. Evaporation and transpiration cease at times, and precipitation, in addition to waste waters, must also be handled.

According to Musgrave (*6*) the major factors that affect the intake of water by soil are surface condition and amount of protection against the impact of rain; internal characteristics of the soil mass, including pore size, depth, or thickness of the permeable portion, degree of swelling of clay and colloids, content of organic matter, and degree of aggregation; moisture content and degree of saturation; duration of rainfall or application of water; and season of the year and temperature of soil and water.

Musgrave also stated that, in the same soil, intake rates were higher when irrigation was applied by flooding than they were from artificial rainfall; infiltration rates increased progressively from bare ground to row and cover crops; infiltration rates increased progressively for more than 20 years after a soil was taken out of cultivation; seepage was better when the soil was protected by mulch, burlap, or grass from surface compaction by raindrops; rates were better when wheat stubble was left than when the area had been burned off; and infiltration rates increased with temperature.

In a 72-hour continuing test with varying water and soil temperatures, the infiltration rate varied diurnally with the temperature from 0.18 inch per hour at 35° F. to 0.54 inch per hour at 70° F. Nearly an exact correlation was found between infiltration and viscosity. Musgrave also included a tabulation of more than 100 soil types tentatively arranged according to their minimum infiltration rates.

Treatment and Drainage

Waste is purified by micro-organisms as it filters through the soil. General principles of filtration indicate that progressively higher BOD reductions, within limitations, are achieved by finer filtering materials, lower rates, and warmer temperatures. Although much progress has been made in sewage treatment, we still have nothing that can produce a better effluent than the intermittent sand filter. The theory of sand filter operation indicates that the best results are achieved by giving the filtering media a chance for aeration.

Vegetation and drain tile should help maintain aeration of the soil, but intermittent operation may be advisable at times. A nearly complete removal of suspended solids and a large reduction in bacteria will be achieved by percolation through the soil pores. In addition to the treatment the wastes receive, irrigation usually acts as an effective flow equalization unit in distributing percolate flow and strength over 24 hours rather than the 6 to 8 hours per day that small factories operate, and stream improvement is greater than the degree of treatment indicates.

If a system is operating satisfactorily and has been properly located, there should be little danger of contaminating wells unless the disposal field is in an area with creviced limestone

near the surface of the ground or unless the waste contains sulfite liquor. This type of waste is acidic and concentrated, responds slowly to biological treatment, and can cause pollution over a long distance and time.

Some soils are naturally well drained, and, in others, drain tile can frequently be used to advantage. Drainage not only permits higher volumetric loadings but removes concentrated salt solutions and, through soil re-aeration favors the treatment processes involved in waste stabilization.

Care must be exercised in using drain tile. Difficulty from earlier drain tiling occurred at some dairy and cannery spray irrigation fields. Short circuiting due to shallow depth or broken tile and the effects of strong wastes must be watched. A minimum tile depth is 2½ feet; vegetation growths increase with drain tile to depths of 3 or 4 feet. The water table between the tile lines will be arced, but even on tight soils it is doubtful if a distance of less than 20 feet between lines is warranted.

An open ditch or a nearby stream with a water level several feet lower than the furrows helps drainage. An irrigation system might be laid out parallel to the bank or on the inside loop of a meandering stream to insure good drainage.

Conclusions

In general, waste irrigation has accomplished a good degree of treatment at low cost. Adverse effects have occurred in only a few cases. Waste irrigation is not a cure-all but rather should be considered as another method of treatment that can be used when conditions are suitable.

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Epidemiology Course for Nurses

A refresher course in communicable disease control stressing epidemiological principles and techniques will be held April 20 through May 8, 1959, at the Communicable Disease Center, Atlanta, Ga., for public health, industrial, and other nurses having supervisory, teaching, or consultant duties.

Courses include epidemiological principles, the laboratory and statistical methods in field epidemiology, and nursing care in communicable disease, for which field practice can be arranged.

There is no fee for the course. Applications should reach the Center by April 1, 1959. They may be obtained from the Chief, Nursing Section, Epidemiology Branch, Communicable Disease Center, Public Health Service, 50 Seventh Street, NE., Atlanta, Ga., or from State health departments.

The Epidemiology of Leptospirosis in the United States

MILDRED M. GALTON, Sc.M.

DURING the past 70 years extensive investigations have shown that leptospirosis occurs in humans and animals in all parts of the world and that it is not a single disease but a group of diseases caused by a variety of leptospiral serotypes. Although considerable attention has been directed to the study of leptospiral infections by European and Asian workers since the early 1930's, much of our knowledge regarding the epidemiology, public health importance, and distribution of these diseases in the United States has been gained only during the past decade.

The epidemiology of the leptospiroses has been shown to follow a characteristic pattern based, in part, upon the fact that they are zoonoses, diseases transmitted from animal to animal and from animal to human. The chain of transmission, with rare exception, stops with human infection.

For many years rats and dogs were considered to be the primary animal carriers, but as the search for leptospires continues the host range broadens not only among domestic animals but in a variety of feral mammals (*1*). Leptospirosis now constitutes a major problem in cattle and swine, and in some areas sheep, goats, and horses become infected. The rat is one of many rodent carriers including mice, voles, and shrews (*2–4*). In addition, bats, mongooses, bandicoots (*5*), jackals (*6*), foxes, opossums, raccoons, skunks, and wildcats (*1*) have been found infected. In these host animals, leptospires become localized in the kidneys and may be found in the lumina of the convoluted tubules. They may be shed in the urine for long periods.

Each leptospiral serotype usually is thought to have a primary animal host but it may infect other animals, and a so-called primary host for one serotype may become infected with other serotypes or even harbor two types at the same time (*7*). A classic example of this is *Leptospira canicola*, found principally in dogs; it has also been isolated from cattle (*6*), swine (*8*), and jackals (*6*), and serologic evidence suggests it may infect raccoons (*9*). Dogs have been found to harbor at least nine other serotypes (*10*).

Differentiation of the rapidly increasing number of pathogenic leptospiral strains is highly important from an epidemiological and epizootiological point of view. This became apparent to the Dutch workers in the early 1930's who found that classification of leptospires must be based upon serologic analysis. During the next 20 years these investigators studied antigenically distinct strains isolated in various parts of the world and developed techniques for serologic identification. Finally, in 1954, Wolff and Broom (*11*) published a suggested classification scheme based on antigenic analysis which included 34 leptospiral serotypes isolated from man and animals. In the 3 years since this report, approximately 25

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additional serotypes have been described in Australia (*12,13*), Africa (*14*), Europe (*15*), and Malaya and the United States (*16*).

Serotypes in the United States

The primary *Leptospira* serotypes in the United States appear to be the more common types, *L. icterohemorrhagiae*, *L. canicola*, and *L. pomona* in domestic animals and humans. However, 7 other serotypes have been isolated, and serologic findings suggest the presence of at least 2 others. The cause of "Fort Bragg" fever was identified as *L. autumnalis* 8 years after the initial outbreak (*17*). Six years later the first animal host for this type in the United States was detected when the organisms were isolated from the kidneys of raccoons trapped in southwest Georgia (*18*). *L. ballum* has been found frequently in rural house mice and opossums and occasionally in rats and laboratory mice (*19,20*). Recent evidence has shown that 1 proved and 7 probable human cases due to *L. ballum* contracted from Swiss white mice occurred among laboratory workers at the Public Health Service Rocky Mountain Laboratory, Hamilton, Mont. (*21*). Serologic evidence suggests the presence of *L. bataviae* infection in humans (*22*), *L. sejroe* in cattle (*23,24*), and *L. grippotyphosa* in humans (*25*) and cattle (*23*). During recent cultural studies at the Communicable Disease Center's Newton Field Station, Ga., on wild mammals, *L. grippotyphosa* was isolated from raccoons trapped within 60 miles of a Florida farm on which cattle showed antibodies to *L. grippotyphosa* in 1952. In addition, these studies have revealed the presence of *L. pomona*, *L. australis* A, three serotypes that belong to the *mitis-hyos* serogroup, one of which has been tentatively designated *L. bakeri* (*16*), and a member of the *hebdomadis* serogroup in wild mammals. It is notable that 61 percent of the leptospiral isolates from striped skunks proved to be *L. pomona*. The highest prevalence of infection has been found in the striped skunk, opossum, and raccoon although occasional isolations have been obtained from the spotted skunk, the gray fox, and the wildcat.

Although comparatively little attention has been directed toward the study of wild mammals elsewhere in the United States, Reilly reported serologic evidence which suggested *L. canicola* infection in raccoons in New York (*9*), and Roth recently isolated *L. pomona* from opossums in Louisiana (*26*). In a recent survey of wild animal serums in Ohio by the divisions of wildlife and animal industry, Ohio Department of Agriculture (*27*), leptospiral antibodies against *L. pomona* were detected in 43 (19 percent) of 224 samples from deer, 16 (22 percent) of 70 serums from raccoons, 14 (25 percent) of 55 serums from foxes, and 6 (54 percent) of 11 serums from skunks. Current information regarding the occurrence of leptospiral serotypes in the United States is summarized in table 1 (*28*).

Transmission

In the transmission of leptospiral infections to humans, the animal carriers which may become urinary shedders after acute, mild, or more frequently inapparent infection, serve as important foci. Infections of humans and other animals result from direct or indirect contact with infected urine of these shedders. For example, direct contact may occur when people care for sick animals, fondle a pet dog, or handle the tissues of infected animals in abattoirs. Indirect contact occurs when the organisms are excreted in water or moist soil, and people are subsequently exposed while swimming, working, or otherwise coming in contact with the contaminated environment.

Although arthropod vectors have not been incriminated as yet in the transmission of leptospirosis in nature (*29,30*), several investigators have been able to infect ticks by allowing them to feed on infected guinea pigs or hamsters. These experimentally infected ticks transmitted the disease to normal animals. However, recently *L. grippotyphosa* was isolated from the European tick, *Dermacentor marginatus* S, from cattle in Russia where isolated cases of leptospirosis had occurred among farm animals (*31*).

During the acute phase of leptospirosis in lactating animals, leptospires may be shed in the milk, but no human cases have been attributed to drinking infected milk. This may be explained by Kirschner's (*32*) observation that

Table 1. Occurrence of leptospiral serotypes in the United States

Serotype	Known host	Occurrence			
		Man	Dogs	Cattle	Swine
L. icterohemorrhagiae	Rat	Common	Occasional	Rare [1]	?
L. canicola	Dog, cattle	Occasional	Common	Rare	Rare.
L. pomona	Swine, skunk, raccoon, wildcat, opossum.	Occasional	Rare	Common	Common.
L. autumnalis	Opossum, raccoon	Rare	?	?	?
L. ballum	Mice, gray fox, opossum, wildcat, rat, raccoon, striped skunk.	Rare [1]	?	?	?
L. grippotyphosa	Raccoon, red fox	Rare [1]	?	Rare [1]	?
L. bataviae	?	Rare [1]	?	?	?
L. sejroe	?	?	?	Sporadic [1]	?
L. hebdomadis serogroup (LT117).	Opossum, raccoon	?	?	?	?
L. australis A	Opossum, raccoon, gray fox	Rare [1]	?	?	?
L. bakeri [2]	Opossum	?	?	?	?
L. mitis-hyos serogroup (LT81).	Opossum, raccoon, skunk, fox	?	?	?	?

[1] Serologic evidence only. [2] *Mitis-hyos* serogroup.

whole milk is leptospirocidal and the organisms survive in it only a few hours.

The leptospires usually enter the body through the mucous membranes of the conjunctivas, nose, or mouth, or abrasions on the skin. It is doubtful that these organisms penetrate the intact skin, and it is unlikely that the digestive tract is an important portal of entry since the pH of the stomach is usually such that the organisms may be quickly destroyed.

Environments that favor the survival of leptospires outside the body include moist soil, stagnant ponds or slow-moving streams that are neutral or slightly alkaline, and a temperature of 22° C. or above. When these conditions exist in nature, leptospires may survive several weeks (*33,34*).

Outbreaks and Sporadic Cases

Under such environmental conditions, several large outbreaks have occurred in the United States following swimming in contaminated water. Since 1940, there have been 4 outbreaks in Georgia (*28,35,36*), 1 in Alabama (*37*), and 1 in Wyoming (*38*) involving more than 150 in-

Table 2. Reported outbreaks of leptospirosis in the United States [1]

Date of onset	Location	Number of cases	Age range	Probable source	Leptospiral serotype involved
August 1940	Wrens, Ga	35	16 (average)	Offal from slaughtered cattle in creek.	*L. pomona.*[2]
July–August 1942, 1943, and 1944.	Fort Bragg, N. C	[3] 40	Young adults (soldiers).	?	*L. autumnalis.*
August 1942	Jackson Hole, Wyo	[4] 24	15–19	Dogs, deer, or other animals.	*L. canicola.*
August 1947	Calvary, Ga	10	13–24	Dead mule in creek (?).	?
August 1949	Swainsboro, Ga	12	Young adults	Cattle	*L. pomona.*[3]
July 1950	Geneva, Ala	50	Adolescents and young adults.	Swine	*L. pomona.*[3]
July 1952	Columbus, Ga	26	5–20 and two adults	Swine, dogs, cattle	*L. canicola.*

[1] With the possible exception of the Fort Bragg outbreaks all were attributed to swimming in water contaminated by infected animals. [2] Serologic evidence only. [3] Each year. [4] Nine confirmed serologically.

dividuals. All these waterborne leptospiral outbreaks followed a similar pattern. They occurred in the late summer during drought periods; there was presumed contamination of a stagnant pond or slow-moving creek by urine from infected animals and transmission to humans by immersion in the contaminated water. The patients were young, primarily children ranging in age from 5 to 16 years but also some young adults.

An outbreak of pretibial fever occurred among troops at Fort Bragg in August 1942 and again in the summers of 1943 (*17*) and 1944 (*39–41*). All patients were quartered in the same general area of the post. Many had been swimming in the nearby ponds but not all, so the source of their infection remains obscure. These reported outbreaks are summarized in table 2 (*28*).

An unusual family outbreak was reported recently by Haunz and Cardy (*42*). The family, including the parents and seven children 5 to 16 years of age, lived in a converted boxcar without sanitary facilities. Drinking water was kept in a bucket, and the family dog occasionally drank from this bucket. The dog was sacrificed and leptospires were demonstrated in sections of kidney tissue. All members of the family became ill within 1 month.

In recent years, reported human cases of leptospirosis in the United States have increased. Cases reported from 1905 to 1948 were summarized by Molner and his co-workers (*43*) according to geographic distribution. During this 43-year period there were 220 cases in 24 States, 8 cases unspecified as to location, and 78 cases in Michigan reported by these authors, making a total of 306 cases for the period.

In contrast, a summary of patients showing positive serologic tests in CDC's laboratories during a 5-year period (1953–57) plus cases reported to CDC by State health departments or to the National Office of Vital Statistics during this time revealed a total of 445 cases in 40 States. In addition, 94 cases occurred in outbreaks reported between 1951 and 1956 (fig. 1).

Occupational Hazards

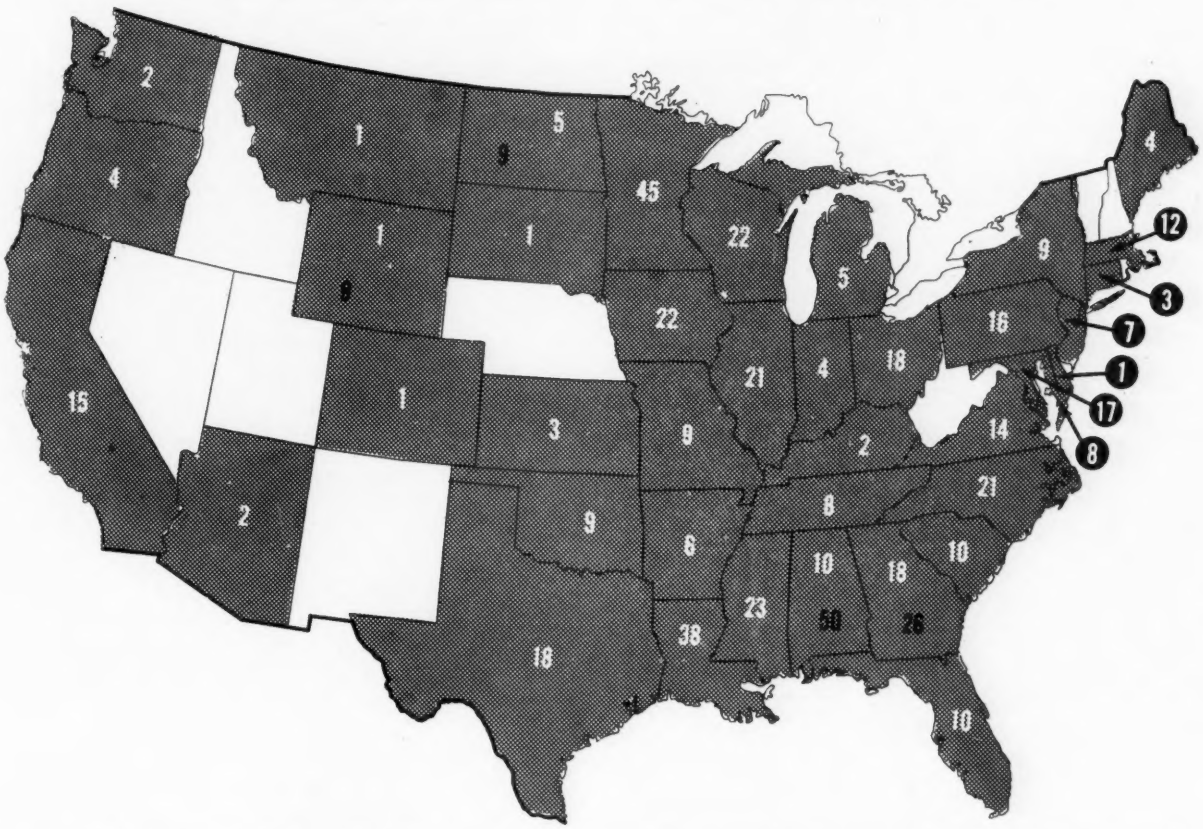
The leptospiroses are frequently referred to as occupational diseases. Certainly, opportunities for exposure are encountered more frequently by veterinarians, animal husbandrymen, swine herdsmen, and workers in abattoirs, sewers, dairies, and poultry and fishhouses.

In Europe, Asia, and Australia leptospirosis is an important health and economic problem among agricultural workers, particularly in the ricefields and canefields (*44,45*). The apparent lack of this problem among agricultural workers in the United States may be attributed to higher living standards and to mechanization of agricultural operations. For example, in Italy the flooded ricefields are worked by hand laborers in their bare feet; in the United States the work is done mechanically. In the United States also, protective clothing, boots, or heavy shoes are usually worn to perform other tasks on farms requiring contact with contaminated soil.

During the past 4 years information has been obtained regarding 130 cases of leptospirosis that occurred in 30 States and the District of Columbia. Knowledge of these cases came primarily from serologically positive serums referred by State health departments to the Diagnostic Microbiology Unit, CDC. Subsequent inquiry to the State epidemiologists usually resulted in a history of the case. Others were reported by State health departments or the National Office of Vital Statistics, or they were investigated, on request, by the Leptospira Research Laboratory staff. Information concerning the probable source was obtained on 89 of the 130 cases. Of these, 32 (36 percent) had had contact with infected cattle or swine either in abattoirs or on farms; 23 (26 percent) had been drinking, swimming, or accidentally immersed in presumably contaminated water; 14 (16 percent) had had contact with dogs in their homes or in veterinary hospitals; 12 (13 percent) were exposed to rats; 3 (3 percent) to wild animals; and 5 (6 percent) to other animals or possibly contaminated environments in their occupation. Of these 5 individuals, 1 was a bulldozer operator, 1 a tractor driver, 1 a ricefield worker, and 1 had contact with an infected goat. The fifth person had been confined to a city jail for approximately 10 days prior to onset and may have had contact with infected rodents.

The fact that the probable source of more

Figure 1. Occurrence of human leptospirosis in the United States, 1953–57.



NOTE: 445 patients (white figures) showing positive serologic tests in CDC laboratories and cases reported by State health departments, 1953–57. 94 cases (black figures) reported in outbreaks, 1951–56.

than one-third of these cases was found to be contact with infected cattle or swine may be attributed, in part, to the rapid spread of bovine leptospirosis in the United States. York (*46*) reported occurrence of the disease in only 12 States prior to 1951. By 1956 it had been recognized in 42 States, according to data obtained from a summary of animal morbidity reports sent to CDC, published reports, and positive serum samples examined at CDC (*28*). In 1954 the Agricultural Research Service of the U. S. Department of Agriculture (*47*) estimated that annual losses from bovine leptospirosis were more than $112 million, or $25 million greater than losses from bovine brucellosis.

Since it has been estimated that 25 percent of the dogs in this country have or have had leptospirosis and 25 to 50 percent of these become temporary carriers, the opportunities for exposure among children would be expected to be high, although Broom in England (*48*) observed a low infectivity rate among dog owners and their families. Recent investigations in the Leptospirosis Research Laboratory on leptospirosis in dogs in the Atlanta, Ga., area failed to detect leptospiral antibodies in serum from about 50 persons who had contact at home with 10 dogs infected with *L. canicola*. However, of the 14 persons with leptospirosis throughout the United States in which exposure to dogs was known, 10 had contact with sick pets in their homes and 4 worked in veterinary hospitals.

Age, Sex, and Seasonal Prevalence

As a result of environmental and occupational factors, the epidemiological pattern of human leptospiral infection has certain charac-

teristic features related to age, sex, and season. Although these infections may attack individuals of all ages, conditions are most favorable for infection of young adults. Beeson and Hankey (*49*) observed that the leptospiroses occur most frequently in the United States in males above the age of 15 years due to the occupational factor. In a series of 24 cases they found the age range was 10 to 55 years, but 19 (70 percent) were less than 30 years of age and only 5 of the patients were female. A distinct seasonal incidence was observed, with 10 (41 percent) of the cases occurring in August. Molner and associates (*43*) reported a similar age, sex, and seasonal distribution among 78 cases studied in the Detroit, Mich., area. In this series, 70 (90 percent) of the patients were more than 20 years of age and 73 (93 percent) were male, providing further evidence of an occupational relationship. Although sporadic cases occurred throughout the year, a definite increase was noted from August through November.

During the past 4 years the Leptospira Research Laboratory has gathered information on 130 cases of leptospirosis in 30 States and the District of Columbia. Patients ranged in age from 2 to 73 years, but nearly half were between the ages of 20 and 39 (fig. 2), and 88 percent were male. The highest incidence, 41 percent, occurred in the 3-month period from July through September (fig. 3).

Figure 2. Age distribution of 71 cases of leptospirosis in the United States, August 1954–May 1958.

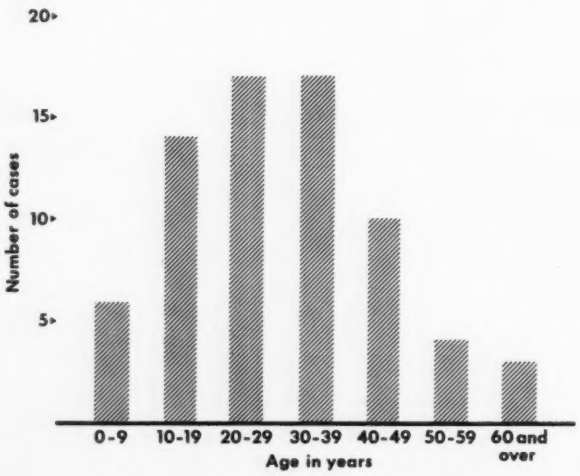
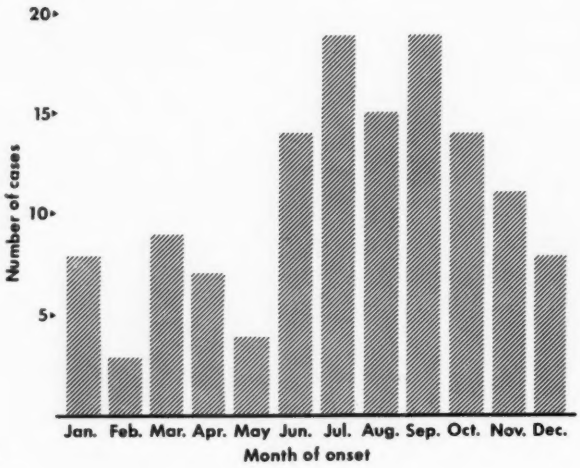


Figure 3. Seasonal distribution of 130 human cases of leptospirosis in the United States, August 1954–May 1958.



These observations regarding age, sex, and seasonal distribution of the leptospiroses in the United States are in accord with the findings of European investigators with possibly one exception. In certain agricultural areas where fieldworkers are predominantly women, there may be more women than men with leptospirosis (*44*).

Summary

The leptospiroses are a group of diseases caused by a variety of leptospiral serotypes. They are associated with a broad animal host spectrum and are transmitted from these animal carriers to other animals and to man. Transmission occurs by direct contact with infectious urine and with tissues of infected animals or indirectly through contact with contaminated water. The mucous membranes and abraded skin are usual portals of entry.

While *Leptospira icterohemorrhagiae*, *Leptospira canicola*, and *Leptospira pomona* have appeared to be the primary serotypes involved in human and domestic animal infections in the United States, the detection of serotypes hitherto unrecognized in this country emphasizes the need for public health, medical, and veterinary laboratories to search for them. Further study of the new feral mammal hosts will be necessary to determine prevalence of infection in other parts of the country and to determine their role

in the epidemiology and epizootiology of the disease.

Outbreaks have occurred in the United States and most other parts of the world as a result of swimming in ponds or slow-moving creeks contaminated by domestic or wild animal shedders. These outbreaks are usually observed during the late summer and affect primarily adolescents and young adults. Sporadic cases occur frequently from occupational exposures among veterinarians, abattoir workers, sewer workers, dairy workers, poultry and fishhouse workers, and animal husbandrymen. Information concerning the probable source of 89 human cases of leptospirosis that occurred in the United States from 1954 through 1957 revealed that 32 (36 percent) had had contact with cattle or swine either in abattoirs or on farms. The disease has been reported in the United States predominantly in young males in the 20–39 age group, and it appears more prevalent between July and November than in any other months.

Recognized cases of leptospirosis in humans have appreciably increased in the United States, and the disease in cattle has spread rapidly.

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Control of Leptospirosis in Man and Animals

ROBERT W. MENGES, D.V.M., M.P.H.

COMPLETE control of leptospirosis in man depends on the elimination of the infection in carriers. After acute or, frequently, inapparent infections in domestic and wild animals, the organisms become established in the kidneys and may be shed with urine chronically. Urinary shedders of leptospires are primary vectors: the infection passes to other animals and to man by direct or indirect contact with infected urine.

Preventive measures have most often been aimed at the leptospire outside the body of its host (*1*). In the past, control methods pursued the destruction of the leptospire by chemical agents, heat, or desiccation; or they were designed to prevent the leptospire from gaining access to the susceptible host by ratproofing, confinement, or protective clothing. At present, immunization of susceptible populations and elimination of carriers by antibiotic treatment are being emphasized. In some instances, however, the best means of control may lie in the prevention of contact. For example, in the United States, most outbreaks of leptospirosis in humans (primarily in children and young adults) have occurred as a result of swimming in stagnant pools or streams contaminated by infected urine from animals. Notices placed in schools and service establishments might prove effective in warning swimmers of their risk.

Vaccines

Leptospirosis among certain occupational groups such as abattoir workers, dairy farmers, animal husbandrymen, veterinarians, sewer workers, plumbers, and miners may be controlled by vaccination. Early investigators reported the excellent immunogenic properties of *Leptospira icterohemorrhagiae* killed with phenol (*2*), heat and phenol (*3*), and heat alone. In Japan, thousands of persons have been inoculated successfully with these vaccines. Babudieri (*4*) has controlled leptospirosis caused by *L. icterohemorrhagiae* and *L. bataviae* in ricefield workers in Europe by vaccinating with a formalized vaccine. The choice of serotypes in the vaccines was determined by the epidemiological situation. In countries where the disease is a serious problem, immunization of the population at risk has not been widely practiced.

Although vaccines have not been used for humans in the United States, their use in domestic animals is becoming quite commonplace. As a means of controlling the disease by establishing immune animal populations, vaccination holds great promise. The vaccines that have been developed include the egg-propogated *L. pomona* bacterin of York and Baker (*5*), and the culture bacterin of Brown and associates (*6*). Hoag and Bell (*7*) have described a soluble antigen which protected calves, and a strain of *L. pomona* attenuated through more than 500 egg-passages has been evaluated as an immunizing agent by Kenzy and coworkers (*8*).

From 1 to 3 weeks are required for the development of immunity following vaccination, and

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the duration of this immunity has been reported for periods varying from 18 to 20 months (*8*). Young calves may be protected by vaccination of the dams during late pregnancy (*9*) and young pigs by vaccination of the sows (*10*).

Stoenner (*11*) has suggested prompt vaccination of an entire herd when the disease is diagnosed early. Since leptospirosis may spread rapidly, any delay in vaccination would minimize the protective effect of the vaccine. If abortions or other symptoms of the disease have occurred for 3 or more weeks, an immunizing agent is of little value in preventing further losses. Herds of this category should be tested, and only serologically negative animals, replacements, and calves born during the next 6 months would require immunization.

Improvements in the vaccines are needed before general control by vaccination can be achieved. None of the vaccines currently in use provides protection against all the leptospiral serotypes that have been isolated from animals in the United States. The vaccines available for cattle and swine provide protection against *L. pomona*, and those for dogs, against *L. canicola* and *L. icterohemorrhagiae*.

Herd Management and Sanitary Measures

Herd management and sanitation have considerable value in prevention and control. The factors in general herd management which afford protection against leptospirosis include isolation of sick and aborting animals, provision of sanitary quarters that can be easily cleaned, and provision of sanitary feeding and watering conditions, with special emphasis on watering tanks that prevent contamination. New animals should be held in quarantine for a period of 1 month or more before they are introduced into the main herd.

When the disease is diagnosed during the early phase of an epizootic, Stoenner (*11*) recommends prompt alteration of husbandry methods to effect an environment unfavorable for the spread of infection. Feed and water should be given in a manner which would prevent contamination with urine. Natural streams or surface waters are readily contaminated with urine of recovered carriers and should not be used as sources of water. Farm ponds located in pastures should be drained or fenced and the cattle should be watered from tanks. The aprons surrounding these tanks should be free of seepage or overflow. Roughage should be fed from portable racks which can be moved frequently. Whenever possible, crowding of cattle in confined quarters should be avoided. On dairy farms, milk from cows should be pasteurized before being fed to baby calves. Horses, swine, and cattle should be kept in separate pastures.

Treatment of Carriers

Curing carriers by treatment has been tried by several workers. Ringen and co-workers (*12,13*) reported on attempts to eliminate the carrier condition in cattle infected with *L. pomona* by dihydrostreptomycin and terramycin therapy. Their findings suggested that dihydrostreptomycin given intramuscularly at a level of 5 mg. per pound of body weight every 12 hours for 3 days eliminated the carrier state. They demonstrated also that 2.5 mg. of tetracycline hydrochloride per pound of body weight was the minimal dose, since the 2.0 mg. level failed to prevent the development of carrier animals. The tetracycline hydrochloride was given intramuscularly once daily for 5 days. Baker and associates (*14,15*) found that in swine, disinfection of urinary shedders was accomplished as a result of 7-day feeding of terramycin at 500 gm. per ton of rations. He concluded that a program of high-level, short-term terramycin feeding to pregnant sows and gilts would significantly reduce losses from leptospirosis. Brunner and Meyer (*16,17*) found that streptomycin and aureomycin were possibly effective in clearing the urinary carrier state of hamsters and dogs infected with *L. icterohemorrhagiae* and *L. canicola*.

Wild Animals

Vaccination and the use of antibiotics may aid in the control of leptospirosis in domestic animals, but these methods cannot be applied to leptospiral shedders in wild animal populations. This problem may be approached by two methods; active campaigns to destroy carrier

animals by trapping or shooting, or the destruction of the leptospires in contaminated soil and water by disinfectant agents. The method used will depend on the circumstances.

In Japan, Tokyama (*18*) applied calcium cyanamide as a fertilizer to some of the ricefields in an area where Weil's disease was very common. As a result of this treatment, the number of cases of Weil's disease was markedly reduced. In the United States, Molner and co-workers (*19*) studied a poultry-dressing establishment in which 18 cases of Weil's disease had occurred. The premises were heavily infested with rats, and the worktables were incompletely cleansed of blood and offal at night. *L. icterohemorrhagiae* was isolated by washing the tables with saline in the morning and injecting this fluid into guinea pigs. When the tables were swabbed with diluted hydrochloric acid in the evening, similar inoculations failed to infect guinea pigs.

Laboratory Animals

Laboratory animals may also serve as a large reservoir of leptospires. *L. ballum* has commonly been found among laboratory white mice (*20*), *L. icterohemorrhagiae* among laboratory rats (*21*), and natural infection with this serotype has occurred among guinea pigs (*22*). In Europe, *L. grippotyphosa* has been isolated from naturally infected hamsters (*23*). Stoenner (*24*) has recently reported infection of eight laboratory employees who had close contact with Swiss albino mice which were infected with *L. ballum*. Control of the disease in laboratory animals involves recognizing and destroying the infected animals, or possibly curing urinary shedders by the use of antibiotics.

Conclusion

It may be quite some time before effective control measures are developed for leptospirosis in the United States. At the present time we are just beginning to recognize leptospirosis as a disease of public health importance. Before we can control the disease, its extent must be determined in each locality. More cultural studies must be conducted to determine the serotypes present. After the serotypes and the animals that are important reservoirs are known, effective control measures can be instituted.

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Summer Session in Health Statistics

A second training program in statistics applied to health sciences will be held from June 18 to August 1, 1959, by the University of Michigan Graduate School of Public Health in cooperation with the accredited schools of public health in the United States.

The program is made possible by a research training grant from the Division of General Medical Sciences, National Institutes of Health, Public Health Service.

The courses, for which academic credits are given, are designed to meet the needs of statisticians, epidemiologists, senior public health personnel, professional workers in the health sciences, graduate students in statistics and health sciences, teachers of public health statistics, and others interested in the subject matter to be covered.

The course titles are statistical methods in public health, management of health agency records, registration and vital statistics, biostatistics in the health sciences, demographic methods in public health, statistical methods in epidemiology, sampling techniques in the health sciences, advanced biostatistics in the health sciences, and statistical methods in biological assay.

For further information, write Dr. F. M. Hemphill, Director, Summer Program Statistics in the Health Sciences, School of Public Health, University of Michigan, Ann Arbor.

What We Know About Alcoholism in Industry

HARRISON M. TRICE, Ph.D.

FAR LESS is known about alcoholism as it affects on-the-job work experiences of the employee who is a problem drinker than is commonly believed. The cost of problem drinking employees to their employers, for example, has sometimes been described as an annual "billion dollar hangover." Significantly higher rates of on-the-job accidents and job absenteeism are attributed to the problem drinker as compared with the rates of nonalcoholic employees.

Evidence to back up these alleged work characteristics is nevertheless quite sparse. The simple truth is that what we do not know about the work experiences and behavior of problem drinking employees greatly exceeds what we do know (*1*).

There have been some scattered estimates in widely separated companies regarding the cost to the employer of problem drinkers. But these merely suggest that in some job situations such an employee is a costly personnel item while in others he is a relatively minor expense item. Furthermore, his work-related accidents have not been studied in any systematic fashion to discover whether his rate is any higher than that of nonalcoholic employees. Even absenteeism, about which most is assumed to be known, has not been effectively studied with reference to such variables as job types, job status, and stage in the development of alcoholic disease.

Despite this general lack of substantial data about the work behavior of the employee with a drinking problem, some tentative descriptions of the work experiences of alcoholics can be made with a fair amount of confidence. Moreover, there is a slowly developing body of data that can be labeled "things we know less about" but concerning which some hunches are available, even though there are fewer data to back them up than those experiences we can describe tentatively. In short, we can classify what we know about the industrial aspects of alcoholism into data that give us some reasons to believe they are reliable, and data that are far less reliable, but which nevertheless provide us some basis for hunches.

The fact that early- and middle-stage alcoholics continue to work is the work characteristic on which we probably have the most substantial data. Of some 700 work histories of members of Alcoholics Anonymous I collected, only 4 members reported they did not work regularly during the middle phases of their alcoholism. There seems to be little doubt that the alcoholic works regularly while his malady is in its incipient and middle stages. Typically he continues on his job for years as the symptoms of compulsive drinking develop at a slow but steady pace. He gradually, almost imperceptibly, loses control of his drinking until he comes to the point where, once he begins to drink, he finds it almost impossible to stop voluntarily.

The symptoms of the early and middle stages

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that accompany this loss of control are not the dramatic ones of late-stage alcoholism which most people think of when they hear the term. Consequently, he is unrecognized as an alcoholic and continues to work actively at his job or profession even though he is well along the road to alcoholism. It is this unrecognized, covered-up employee with a drinking problem who constitutes an especially difficult personnel matter for management.

What are some of these early and middle symptoms (*2*)? Since the alcoholic drinks to experience a sense of physical and emotional well-being, he soon discovers he must drink a lot more than he did a few years before because it takes more liquor to get the same "glow." So he begins to drink everyone under the table, and his friends often observe how well he can "hold his liquor." Thus his consumption increases markedly. So do his periods of temporary amnesia. Dubbed "blackouts" or "pulling blacks," these are not periods of physical unconsciousness. They are drinking episodes during which the developing alcoholic appears to an observer much like any other relatively drunk person. The difference, however, is the inability of the early-stage alcoholic to remember what happened during the drinking episode. At first these blackouts are sporadic, but in a few years they become regular experiences.

During the early period he gains a good deal of prestige among drinking friends for these drinking exploits. His capacity to drink and his inability to remember what happened are often sources of group recognition for him; the feelings of well-being he gets from drinking are reinforced by group rewards. But gradually his drinking friends begin to think of him as different and he does, too. As a result, he develops a series of psychological symptoms.

He begins to hate himself for not having the willpower of others, and he finds in alcohol a temporary relaxation of this self-hate. But upon sobering up, he discovers the self-hate is still there, along with an energy-sapping hangover. So, unlike the nonalcoholic with a hangover, he turns to more alcohol in an effort to manage the twin agonies of emotional remorse and hangover pain. At the same time he begins an intense drive to refute the growing realization that he has a drinking problem. His excuses for drinking become exaggerated, often bizarre. He vigorously denies there is anything wrong, frequently going to work when in bad physical and emotional condition just to prove it. He often seeks out persons who "drink like I do" in an effort to find a congenial set of friends who will not increase his guilt about his drinking (*3*).

Efficiency Decline

These symptoms usually have a direct impact on his work efficiency. It seems to be quite clear that the hangover, the self-hate, the preoccupation with denying there is anything wrong, the loss of control that leads to continued drinking off the job until something outside himself intervenes to stop him, and the anxiety about getting alcoholic relief during the workday reduce substantially his ability to do his job.

This decline in efficiency has numerous facets. The problem drinker begins to procrastinate a great deal, to put off everything except absolutely essential tasks, to fulfill only the immediate requirements of his job. He compromises with quality, accepting second or third "best" because he is unable to concentrate on the details necessary to perform his job well (*4*). A "don't-care" attitude supports the work slowdown. Fatigue saps his energy, and consequently initiative is forgotten. He has a strong tendency to do his job any old way just to get it done. In short, he is content with a mediocre performance. Because he becomes very guilt-ridden about his poor work, typically, he tries to make up for it by spasmodic spurts of output or creativity during which he often does superior work (*5*). This serves as a sign to him that his work is still well done. Actually it is merely a short-lived increase in a general efficiency decline.

Fairly good data also indicate that problem drinkers are rather evenly distributed through all occupational groups as well as many types of businesses and industries (*6*). The old stereotype that visualized the unskilled, poorly educated "drunk" as the typical alcoholic is obviously wrong. Company after company has discovered well-developed problem drinkers among their managerial ranks, and the pro-

fessions appear to be proportionally represented in the alcoholic population. In short, it seems that alcoholic employees appear in substantial numbers in managerial, skilled, unskilled, semiskilled, service, clerical, and professional occupations. When the last stages of alcoholism are reached there is some tendency to gravitate toward the migratory, spot-labor jobs, but this is far from a general trend even at this stage.

The middle-stage alcoholics are apparently rather evenly distributed throughout the various types of American industries (*7*). Construction does not seem to have an unusually low or high number of them in comparison with agriculture or manufacturing. Transportation has substantial numbers, as do finance and service businesses. Government service, including the military, has its quota but, again, not in any unusual concentration.

In addition to this characteristic of dispersion throughout the work world, the middle-stage alcoholic is, in many respects, like any other employee (*6*). He cannot be distinguished by his length of service, marital status, or mode of residence. Although his drinking deviates from accepted limits, he is still part of established social and economic patterns of living.

The type appears to be lodged heavily among male employees in the ages from 35 to 50 years. Certainly female alcoholics exist, probably many more than are currently estimated, and many more women are in the labor force today than 20 or 30 years ago. There are still good grounds, however, for believing that industry will find more alcoholism among men than women. Even more certain is the characteristic that alcoholism is a disorder of the mature years at a time of maximum work expectancy. If it were spread evenly among workers of all age groups, its industrial impact would be far less. Concentrated as it is in the productive years of 35–50, it can impair a large number of workers at the point of their greatest work contribution.

Company Rehabilitation Efforts

Numerous prominent companies have recognized alcoholism as a health problem, issuing personnel policies regarding it and setting up specific procedures to carry them out (*8*). Typically, the policy statements issued (*a*) indicate that the company regards alcoholism as a form of illness and intends to act accordingly; (*b*) explain how the company will aid in the rehabilitation of the alcoholic employee; and (*c*) set the limitations on this aid, that is, the point at which the company will cease to aid in the rehabilitation of such an employee and consider his discharge.

In implementing these policies, various personnel practices have been used. Sickness benefits, pension eligibility, leaves of absence, counseling and referral to outside treatment facilities, and supervisory training relative to the malady have all been offered in various company programs for rehabilitation. However, no one company has used all of these. Most of the programs operate in the belief that rehabilitation does not occur overnight and that recurrence of drinking can be expected. When the employee makes a sincere effort and his "slips" become infrequent, most companies with rehabilitation policies believe there is justification for continuing company aid.

On the other hand, when reasonable aid does not produce or seem to prognosticate any basic change in the drinking pattern, most companies consider termination. Continued aid in rehabilitation under these conditions, they believe, is merely an unwitting support of abnormal drinking and is probably a hindrance rather than an aid to sobriety. Briefly, almost all companies with a treatment policy will, under certain circumstances, discharge an employee because of his drinking. A few companies exhaust all possibilities for every alcoholic, requiring special review before termination. This is especially true for longtime employees.

Extent and Cost to Industry

Data on the extent and cost of alcoholism in business and industry are far less reliable than data on efficiency decline and efforts at rehabilitation. There are grounds only for reasonable guesses. Estimates of the number of employed middle-stage alcoholics have been made in two ways: (*a*) by taking the estimated number of all alcoholics in the total population and making

an educated guess of the number who are regularly employed, and (*b*) by using the estimates made in specific companies as an indication of the number throughout industry. Both of these approaches are questionable at best; however, they provide us with a rough idea of the extent of the problem.

Estimates of the total number of alcoholics have come mainly from the Jellinek estimation formula (*9*), the intricacies of which I will not explain here. It is appropriate, however, to point out that numerous efforts to validate estimates made by the formula have shown considerable success. Thus, an independent survey of the number of alcoholics in a specific locality is compared with an estimation obtained with the formula. In numerous instances the two have agreed closely, leading to the tentative validation of the Jellinek estimations (*10*).

The chief difficulty with this procedure is that no one knows the accuracy of the independent survey against which the estimates were validated. The survey results may or may not correctly reflect the number of alcoholics in the area. Therefore, one set of questionable estimates may be validated against another set of equally questionable data.

On the other hand, the repeated close agreement between the appraisals made by the formula and independent assessment indicates that the Jellinek estimates are far more than conjecture. Apparently, there is a careful approximation in them that merits close attention. In 1955 the formula estimate was 4,500,000 incipient and full-blown alcoholics in the United States.

But how many of these are employed regularly in a definite job? Here the quest becomes very fuzzy. Most observers have played safe and said only half of these were actively employed. At the same time case histories of clinics and work histories of members of Alcoholics Anonymous suggest a substantially higher number in the employed category. But no one knows how to be more precise in any systematic fashion about the estimation.

The figure usually cited is 2 million, or approximately 3 percent of the Nation's labor force. But a particular company may have many more or many less than this percentage. Judging from studies in individual companies, this figure can range from practically none to 10 percent (*11,12*).

But troubles in estimating really start when we try to appraise the costs of alcoholism to American industry and business as a whole. This appears to be not only an almost impossible task but also a gigantic one. When the vast array of factors, both tangible and intangible, affecting the value of an employee to his employer are considered, the difficulty of the task becomes obvious. And, when an effort is made to attach a dollar value to the way in which alcoholism reduces this value, any nationwide effort is extremely questionable. The best we can do is list the various cost factors that may be relevant to a particular company, leaving to the judgment of those who know the organization any actual estimation of dollar cost (*13*).

First, cost of reduced work efficiency is the most apparent factor. This can take many forms such as scrap, spoilage, errors in assembly and shipping, slowdown, fewer sales, increased rejects, and customer complaints. Executive and professional error adds another and even more costly dimension. Second, since many alcoholics appear to have a substantially higher absenteeism rate, they can be costly from this standpoint. Furthermore, companies make training investments in many employees which are lost if termination for alcoholism occurs, and replacing an employee can be expensive. The public relations impact of an alcoholic employee is also a potential cost item along with the sickness support the company may provide for the many related illnesses that accompany alcoholism.

Briefly, the only meaningful cost items come from specific companies who appraise alcoholic employees in specific jobs and attach a dollar value to their cases. This procedure has been attempted in a few instances, and the results suggest that in many situations problem drinkers are very costly to their employers, while in others the cost is relatively modest (*14*).

Absenteeism and On-the-Job Accidents

Again, we do not have very much specific information about absenteeism and on-the-job accidents of alcoholics. There are data indicating that, in general, the absenteeism rate of

a company's problem drinkers is significantly higher than that of nonalcholic workers (*15,16*). Beyond this we have only hunches. However, these suspicions are interesting.

Some grounds exist for believing that "no-report" absenteeism and "partial" absenteeism characterize a developing drinking problem in an employee (*17*). Failure to report his inability to be on the job is often a symptom of the middle-stage alcoholic that distinguishes him from the average absentee. In the early stages, a member of his family may report his absence. But as his problem worsens, his absences will occur without advance notice from anyone. Often he comes to the job only to leave before the day is over (*18*). He realizes he cannot get through the day without a drink, so he leaves. This behavior is most likely in unskilled and semiskilled work which operates on a definite schedule and under close supervision.

There is also some exploratory evidence regarding absenteeism among high-status as contrasted to low-status problem drinkers (*19*). Alcoholic executives, engineers, lawyers, doctors, and other high-status workers apparently have substantially less actual absenteeism than do low-status alcoholics on semiskilled and unskilled jobs. High-status inebriates, however, seem to have a great deal of "on-the-job absenteeism," that is, they come to work when they feel bad from their drinking behavior, but for all practical purposes are "absent." They put in an appearance but merely go through the motions of doing their jobs. Low-status problem drinkers tend to have large amounts of actual "stay-away absenteeism."

Various motivations and work situations seem to account for this difference. The high-status alcoholics, despite their disorder, were motivated to go to work by a sense of responsibility, a desire to deny there was anything wrong, and as a way to reduce their guilt about excessive drinking. The motivations to go to work anyway were reinforced by the fact that once at work, they could get a drink rather easily when they wanted one. They have freedom from close supervision, freedom of schedule, and freedom to move around. Low-status workers did not express these motivations nor enjoy these job freedoms, so their actual absenteeism was consequently higher.

Far more contrary to popular belief are notions about the job accidents of the problem drinker. The belief that his accident rate must be higher than that of other workers is widespread. Yet what meager evidence there is suggests no such sharp difference (*17,20*). Reasons for this evidence to the contrary are numerous. Many jobs involve little exposure to accidents, and safety engineering has removed the dangers from many more. Problem drinkers, scattered throughout all occupational levels, have their share of the safe jobs. Also, the repetitive nature of many jobs and the routine to which an experienced employee reduces his work are a protection to the problem drinker.

Furthermore, an overcautious attitude is part of the problem drinker's defense mechanism. He seems to be overly cautious of job hazards and thus minimizes the chance of accidents. The problem drinker has a keen awareness of alcohol's effect on him and develops a routine for handling it. Finally, two factors act to reduce his actual exposure to accidents. On many days when he believes he is likely to have an accident he resorts to absenteeism; it is impossible for him to have an accident on the job if he isn't there. And, in some instances, fellow workers or a supervisor will see to it that a problem drinker is put on a safe job until he is in better shape to handle a job that exposes him to accidents.

Summary

Although evidence is rather meager, we know the problem drinker is a definite personnel problem for employers. Even though he is only in the middle stages of his malady, not a full-blown, chronic alcoholic, his work efficiency is materially damaged, and often he can be a definite financial liability. Alcoholism in industry is a disorder of the mature years, the time of maximum work expectancy.

Conservative estimates of the number of employees who are alcoholics center around 2 million, and there seems to be good evidence that they are present in substantial numbers in all occupational and industrial groups.

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Something is being done for this type of employee. Numerous companies have a definite rehabilitation policy with specific procedures for implementing it. Most companies with a policy concerning treatment will, under certain circumstances, discharge an employee because of his drinking.

The inebriate with a high-status job has more "on-the-job absenteeism" than the low-status worker. There is little evidence that the accident rate for the problem drinker is higher than that of other workers.

A start has been made on developing more accurate data about such work experiences as accidents, absenteeism, and coverup. In short, what we know about the industrial aspects of alcoholism is slowly increasing. Soon we may be able to describe the job aspects of alcoholism more accurately.

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Trichinosis in the United States

IRVING G. KAGAN, Ph.D.

AMONG all the intestinal nematodes, *Trichinella spiralis* has probably made the best adjustment for a parasitic existence. All stages of the life cycle are parasitic. The sexually mature worms reside in the small intestine and produce larvae which invade the musculature and internal organs of the host. A recent study of 55 experimentally infected hogs revealed the following distribution of larvae in the tissues: diaphragm, 100 percent; stomach, 18 percent; testes, 15 percent; liver, 11 percent; brain, lungs, wall of the small intestine, each 9 percent; pancreas and aorta, each 8 percent; and heart, 2 percent (*1*).

The definitive hosts for this parasite are usually carnivorous mammals, that is, those that eat the flesh and internal organs of infected animals. A survey of 2,433 mammals representing 42 species in Alaska revealed an incidence of infection of 11.7 percent in 23 species (*2*). Some of the infected hosts were aquatic mammals such as seals and white whales, which are primarily fisheaters, indicating that the epidemiology of *T. spiralis* may involve transfer or transient hosts.

In the United States trichinosis is a disease of man and his domesticated pig as well as a sylvatic disease of many wild animal species. A survey of trichinosis from 1953 to 1955 in Iowa emphasizes the sylvatic nature of this disease. Infected with trichinosis were 14 of 119 rats, 31 of 308 foxes, 1 of 40 opossums, 2 of 29 raccoons, 12 of 85 mink, and 2 of 4 coyotes. Examination of 2,184 pigs revealed 1 infection, and 18 of 1,148 pork products contained trichina larvae (*3*). In the arctic areas the polar bear, dog, and wolf are heavily infected.

The incidence of trichinosis in the American population is not accurately known today. Gould believes that a conservative estimate would place the figure at about 16 percent. But in a postscript he states that the incidence is probably more than double this amount (*4,5*). This means that 25 to 50 million Americans carry trichina larvae in their muscles and internal organs. A majority of these infections are symptomless and subclinical. Although most States do not make trichinosis a reportable disease, between 200 and 300 cases are reported each year to the Public Health Service. These are the recognized cases. Clinically, trichinosis has all the earmarks of so many other diseases that in all probability a large number of cases go undiagnosed. The mortality rate for recognized clinical cases was approximately 5 percent in the United States (*4,5*).

The epidemiology of this disease is very well understood. We know how it is transmitted to man, and we know how to prevent its spread in the swine population. We are improving serologic diagnosis in the suspected patient and have made important advances in the treatment of the disease with ACTH and cortisone. In recent years two comprehensive national conferences on trichinosis were held in Chicago, the first in December 1952 and the second in March 1954. The many facets of the control of this disease were adequately covered in the papers presented at these meetings. In this paper I shall outline the problem and review

Dr. Kagan, chief of the Helminthology Unit, Communicable Disease Center, Public Health Service, Atlanta, Ga., presented this paper at the CDC Conference for Teachers of Veterinary Public Health and Preventive Medicine, and Public Health Workers, Atlanta, June 12–18, 1958.

some of the contributions that have been made since those meetings.

Control Measures

Trichinosis in the United States is perpetuated in a very small proportion, 0.63 percent, of the swine population through the feeding of infected scraps of pork collected in garbage (*6*). As of May 31, 1957, the Animal Disease Eradication Division of the U. S. Agricultural Research Service reports that 12,423 farms were feeding garbage in one form or another to swine. Hundreds of communities in the United States sell their garbage and use the funds for civic purposes. It is generally conceded that the prohibition of garbage feeding would drastically cut the incidence of trichinosis in the domesticated pig, but it would probably not eradicate the parasite because of the sylvatic incidence of trichinosis in rats and other scavenging species. The lone infected pig in the Iowa survey (*3*) may well have acquired trichinae by eating a dead infected animal on the farm.

Since a $50 million industry, the collection and use of garbage for swine production, involving approximately 35 percent of the communities of the United States, probably cannot be legislated out of existence, attention has been directed toward another measure, the sterilization of garbage by cooking (*7*). Every State has some type of law or regulation which prohibits the feeding of raw garbage to swine.

Garbage cooked at 100° C. for 30 minutes is freed of living trichina larvae. Approximately 11,747, 94.5 percent, of the 12,423 premises feeding garbage to hogs, report that they are feeding cooked garbage. This salutary situation with respect to the use of cooked garbage was engendered mainly by the necessity of preventing the spread of garbage-borne epidemic disease of pigs, such as hog cholera, vesicular exanthema, foot-and-mouth disease, salmonellosis, tuberculosis, swine erysipelas, and brucellosis. Because of noncompliance by some farmers, the lack of adequate inspection facilities by some State agencies, and the expense of cooking garbage, the control of trichinosis by this method has not been completely successful. Continued education, research, and law enforcement by State and Federal officials will do much to strengthen this very effective method of trichina control.

Inspection of pork products constitutes another means of control. The Federal Government requires that "the respective States allow the sale of garbage-fed hogs for slaughter only at a federally inspected plant or plant having equivalent inspection." In some countries tissue press preparations of each carcass are carefully inspected microscopically for the presence of trichina larvae. In Chile a staff of 22 persons is necessary to process and examine 1,000 pigs a day: 8 trichinoscopists, 4 sample collectors, and 10 assistants preparing 8 slides from each carcass for examination (*8*). It is estimated that an effective program of microscopic inspection in the United States would cost more than $40 million (*9*). For this and other reasons, the microscopic examination of pork has not become a routine procedure in our country.

The freezing of pork is also advocated for killing trichina larvae in infected carcasses. As early as 1914, research by the U. S. Bureau of Animal Industry indicated that refrigeration of pork at −15° C. (5° F.) for 20 days is an effective safeguard against trichinosis in man (*10*). These studies were the basis for the present practice of holding pork and pork products customarily eaten without cooking by the consumer for 20 days at 5° F., 10 days at −10° F., or 6 days at −20° F. In Canada pork is held at −15° C. for 3 weeks in sealed storage lockers inspected by the government (*11*). Quick freezing at temperatures of −37° C. (−34.6° F.) kills trichina larvae in 2 minutes. In the United States today meat packing plants do not have the space to freeze and store the huge volume of pork processed. The cost to the consumer for freezing pork would be approximately 5 cents per pound. This economic factor plus consumer resistance to the purchase of pork that has been frozen and thawed make this type of control impractical and difficult to initiate (*12*).

Sterilization of carcasses by irradiation has been carefully investigated by Gould and his co-workers (*13*). These workers have estimated that facilities using cesium-137 as the source of radiation, costing in excess of $500,000, can

effectively treat carcasses with 30,000 roentgens, enough radiation to make the larvae incapable of completing their life cycle in the host. The cost to the consumer is estimated at 0.23 cents per pound, and the meat is said to be unaltered, healthful, and palatable.

The most effective and the cheapest control method is the thorough cooking of pork by the consumer. If they were aware of the hazards, many persons would not eat uncooked pork or pork products that have been smoked and not adequately heated prior to processing. Informing the producer on the farm about the dangers of feeding raw garbage to his swine and alerting the housewife, food handler, restaurant owner, and others to the dangers of eating pork not thoroughly cooked are among the control measures recommended by previous conferences on trichinosis. But it should be reiterated that placing the responsibility for control of trichinosis on the consumer is not the most efficient method for controlling the disease.

Treatment and Diagnosis

One aspect of the epidemiology of trichinosis should be emphasized. Eradication cannot be accomplished solely by control measures initiated by the large farmer or food processor. A number of trichinosis outbreaks have been traced to pork products that did not pass through federally inspected plants (*14*). The small farmer with a few pigs which are fed table scraps (uncooked garbage) and butchered in local abattoirs account for some of the incidence of trichinosis in the United States.

Since so many trichina infections are subclinical, the question has been raised regarding the necessity of any kind of control. Magath and Thompson believe that persons infected with small numbers of trichina larvae have an acquired immunity which would be destroyed were the disease controlled (*15*). From a public health point of view such a position is untenable. We must strive for the control of all communicable diseases. There is also to be considered another facet of this complex problem that has received very little attention—the evaluation of the deleterious effects of a subclinical infection in an individual. In the rat, infection with trichina larvae reduces the working ability of the animal 49 to 60 percent. Weight loss induced by exercise is 150 to 170 percent greater than in the controls (*16*).

Little attention has been directed toward the use of long-lasting, broad-spectrum chemotherapeutic agents administered in the feed to eliminate *T. spiralis* adults and other intestinal roundworms in swine. In mice, medicated feed containing 0.15 percent cadmium oxide produced a striking reduction in the number of adults and larvae harbored by infected animals (*17*).

The use of a skin test for the diagnosis of infection in pigs has not received much attention in recent years. Soulsby skin-tested animals in England and reported cross-reactions with *Ascaris* infections (*18*). With the application of newer immunochemical techniques, specific antigens could be prepared for this purpose.

Two flocculation serologic procedures are available for the diagnosis of trichinosis: the method of Sussenguth and Kline (*19*), utilizing cholesterol particles, and the bentonite technique of Bozicevich and others (*20*). The Helminthology Unit at the Communicable Disease Center uses the bentonite flocculation test for the diagnosis of trichinosis. We have found this method effective in detecting antibody during acute infections in man and animals. In an experiment with experimentally infected hogs, flocculating antibody was detected from the second to the sixth week of infection in all animals. After the ninth week antibody could no longer be determined (*21*). As a method of diagnosing active infection, the bentonite technique is excellent, but, for the detection of chronic infections, it does not compare with the technique of Sussenguth and Kline. These workers reported that antibody may be detected in infected hogs 1 year after infection (*19*). Utilization of a rapid serologic technique for the detection of infected animals prior to slaughter might under some circumstances be a useful control procedure.

Conclusion

To be successful, any control program for trichinosis must not conflict with the economics of pork production on the farm or at the proc-

essing plant. The control of trichinosis has benefited more from the measures taken to control vesicular exanthema than from all the recommendations made for the helminth disease. This is heartening because any measure taken against the spread of a garbage-borne virus disease will benefit a helminth garbage-borne disease. Although it may never be economically feasible to quick-freeze all pork in order to kill trichina larvae, the storage of pork in freezing compartments of refrigerators and home freezers is doing much to lower the incidence of trichinosis in our country (*12*).

In the not too distant future, we will have to come to grips with the control of this disease. Control will come when the American people are willing to pay the price of consuming trichina-free pork. Until that time the scientific community must continue working on more efficient methods of control and on instructing the public in methods of protecting its health and well-being.

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Synchronizing the Roles Of State Agencies For Traffic Safety

ALBERT L. CHAPMAN, M.D.

SEVERAL years ago I began talking to State and local health workers about traffic accidents and their prevention. There appeared to be a consensus that traditionally this was the business of police officials and traffic administrators.

But when I asked the State motor vehicle administrator of a heavily populated eastern seaboard State whether he thought public health workers had a role to play in traffic safety, his answer was direct and very much to the point. This was the gist of his reply:

"The problem of traffic accidents is so great, we traffic administrators need all the help we can get. We can't take a high-risk driver off the road until there is scientific proof that he is a high-risk driver. We seldom have that proof. We need it badly. At least in the case of drivers with chronic illnesses and disabilities, it would be helpful to have the cooperation of the public health and medical professions in evaluating the degree of risk involved in giving a license to a driver who has such a disease as diabetes, heart disease, or epilepsy."

He quickly pointed out, however, and I believe rightfully, that "motor vehicle administrators and police officials did not want health people trying to run the show."

In short, there is a role for public health workers and physicians in traffic accident prevention . . . and an important role.

In the spring of this year, Dr. James L. Goddard, chief of the Accident Prevention Program in the Division of Special Health Services, Public Health Service, working closely and cooperatively with Basil R. Creighton, assistant executive director of the American Association of Motor Vehicle Administrators, arranged for a 2-day conference between 8 State health officers and 8 State motor vehicle administrators and a few other officials.

It was a very successful conference. Almost within minutes it was realized that State health officers had remained aloof from the problem of traffic accidents in many States on the mistaken assumption that they had no stake in them. And the traffic administrators realized that there were many types of help that they could have obtained if they had sought the assistance of State health departments. Never before have I attended a conference in which two previously unacquainted groups of people worked so single-mindedly toward a common objective.

Because of this singleness of purpose some very constructive recommendations stemmed from the conference. It was suggested, for example, that the relationship of the two agencies in each State be explored by the Public Health Service and that a report of the findings be made available to the American Association of Motor Vehicle Administrators and to the Association of State and Territorial Health Officers.

A sample of some of the facts gleaned from this report shows current participation by State health officers in traffic safety and indicates ways in which they may be able to contribute further.

- State health departments hold membership on only 23 of the 42 governor's committees on traffic safety.
- In only 4 States are cases of diabetes and epilepsy reported by physicians to State health departments. In only 7 States do physicians report cases of these diseases to the State motor vehicle administrator.
- In only 1 State are mental patients reported to the State health department, and in only 10 States are such reports received directly by State motor vehicle administrators.
- Death certificates are sent to motor vehicle administrators by State health departments in 15 States, so that licenses are no longer recorded in the name of dead people.
- In 17 States, cooperative studies are being conducted by the State health department and the State motor vehicle agency. In 12 of these

Dr. Chapman, an Assistant Surgeon General and chief of the Division of Special Health Services of the Public Health Service, presented this paper at the meeting of the Association of State and Territorial Health Officers in Washington, D. C., on October 23, 1958.

States these cooperative studies are associated with the Cornell Automotive Crash Injury Research.

Suggestions for improving cooperation between State health departments and motor vehicle administrators follow.

Driver Licensing

The responsibility for advising State motor vehicle administrators concerning criteria that can be used to limit the driving privileges of persons who are suffering from diseases that may make them high-risk drivers is clearly a medical responsibility in which the entire medical profession must share. The State health department is the logical medium for bringing the State medical association and private physisions actively into the picture.

The weighing of the merits of reporting patients with diabetes, epilepsy, and heart disease to motor vehicle agencies is not a responsibility that should be sidestepped by the medical profession. As in all other problems involving doctor-patient relationships, there are two sides to this question. But serious consideration should be given to the merits of this activity by State health departments and medical societies.

Communication

Whether communication between the State health officer and the State motor vehicle administrator is established and maintained via a governor's traffic safety committee, frequent informal meetings between representatives of the two agencies, a system of regular, frequent exchange of reports, or through working together in cooperative studies, great improvement in the quality as well as the quantity of communication is essential.

Research

Epidemiology long has been considered the domain of health departments. As long as so little is known about the personal factors that contribute so substantially to traffic accidents, it would seem reasonable to expect most State health departments to follow the lead of the New York State Health Department, the California State Health Department, and others in devising, conducting, and supporting epidemiological studies that can give us some of the many answers we now lack concerning driver accident susceptibility. And finally, there remains this question, which State health department personnel, physicians, police officials, and motor vehicle administrators will have to find the answer to: When you have identified the high-risk driver, how do you get him off the road?

Education

There are many facts known to science which, if communicated successfully to the driving public, could reduce the toll of traffic accidents. For example, facts about:

- The effects of drugs, such as the antihistamines, on driving ability.
- The effect of alcohol on reflexes and judgment.
- The effect of fatigue on reaction time.

In addition, there is a vast field ripe for study and investigation by medical and paramedical personnel:

- The effect of emotions on driving ability.
- The personality pattern of chronic traffic violators.
- The motivations of persons who drive in an irresponsible fashion.

The modern American car, although not perfect from the standpoint of safety design, is still a miracle of scientific achievement. Relatively few accidents occur primarily because of mechanical faults or failures.

This cannot be said of American drivers. Almost anyone is permitted to drive a car today under any and all conditions. While our scientists have been busy harnessing the atom, and medical scientists have been successfully confining once epidemic diseases such as malaria and poliomyelitis, relatively little time, money, or attention has been spent in determining the basic reasons why 40,000 Americans are killed by automobiles each year.

To me, all of this is a challenge which has been inexcusably evaded by the rank and file of the public health and medical professions for several decades. The question now is: What are we going to do about it?

Spontaneous Diseases and Their Control in Laboratory Animals

ROBERT T. HABERMANN, D.V.M.

THE NEED for laboratory animals that are free from spontaneous or naturally occurring diseases is being recognized by research workers throughout the United States. Laboratory animals with parasitic, bacterial, and viral diseases make poor experimental animals, produce inferior biological products, and markedly increase the cost of research. Moreover, diseased animals should not be used in research, especially in radiation, nutrition, and blood studies, because the normal physiological reactions or blood counts are not obtained from them. Researchers know that the results of experiments are reliable, trustworthy, and repeatable only if disease-free animals are used.

During the past 10 years, the Comparative Pathology Section and the Animal Production Section of the National Institutes of Health, Public Health Service, have investigated some of the diseases occurring naturally in mice, rats, guinea pigs, rabbits, and hamsters. The purpose of these investigations was to determine the diseases most injurious to these animals and to evaluate some of the methods of disease control and eradication.

External and Internal Parasites

External parasites cause or transmit some inflammatory skin disorders and parasitic and bacterial diseases in laboratory animals. Alopecia and dermatitis may be caused by the biting and sucking of lice, fleas, and bedbugs or by the burrowing of some species of mites. Eperythrozoonosis, transmitted by the mouse louse *Polyplax serrata*, produces a mild anemia in mice. It is caused by *Eperythrozoon coccoides*, a gram-negative, disk-shaped organism that occurs in the plasma and on the red blood cells. The rat louse *Polyplax spinulosa* transmits bartonellosis, caused by rod and coccoid-shaped organisms, *Bartonella muris*. They produce a severe anemia in splenectomized rats.

The intermediate or larval stage of the tapeworm *Hymenolepis nana* is transmitted to mice and rats by ingestion of fleas and meal beetles.

To eliminate these external parasites and control insectborne diseases, we used an insecticide consisting of 0.1 percent gamma benzene hexachloride, 2.0 percent methoxychlor, and 97.9 percent talc. The animal care workers at the National Institutes of Health have used more than a ton of this insecticide, and no deleterious effects due to the medicated powder have been reported.

Benzyl benzoate is effective in treating and controlling ear mange, or ear canker, a common parasitic infestation of rabbits. This inflammatory condition, usually confined to the external ear, is caused by a mite, *Psoroptes cuniculi*.

Diarrhea and death in young rabbits are frequently caused by two species of coccidia.

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Eimeria perforans causes intestinal coccidiosis and *Eimeria stiedae*, hepatic coccidiosis. We eliminated these two protozoan diseases from the rabbit colony by screening for infection through saltflotation fecal examinations and either removing the infected animals from the colony or giving them a saturated solution of sulfaguanidine in their drinking water for a 2-week period. Sanitation and the washing of all green vegetables are also important preventive measures. Since April 1955, after these procedures were adopted, only 12 positive coccidial fecal samples have been obtained in more than 1,400 examinations.

Tapeworms *H. nana* and *Hymenolepis diminuta* are the two common cestodes found in mice and rats. Treating groups of animals by adding 50 mg. of lead arsenate to 20 gm. of ground mouse feed and 100 mg. of the drug to 20 gm. of ground rat feed is effective. Culberton (*1*) reports that 10 mg. of atabrine by mouth for 2 successive days is also effective.

The oxyurids, or pinworms, of mice and rats are *Syphacia obvelata* and *Aspiculuris tetraptera*. These worms occur in the cecum and colon and produce a catarrhal enteritis when present in large numbers. A dose-rate per mouse of 40 mg. of piperazine adipate in 10 cc. of drinking water and a dose-rate per rat of 250 mg. in 50 cc. of water for 3 days for both mice and rats was found to be 95 percent effective in removing oxyurids from mature animals. Females and their litters should be re-treated in 30 days to remove pinworms from unweaned mice that were unable to drink the medicated water.

Although no critical anthelmintic tests have been run, we believe that the piperazine compounds would also be effective in removing the roundworm *Paraspidodera uncinata* from guinea pigs and the pinworm *Passalurus ambiguus* from rabbits.

The larval forms of the tapeworms of the dog and cat are occasionally encountered in laboratory animals. *Cysticercus fasciolaris*, the larval stage of *Taenia taeniaformis*, the tapeworm of the cat, appears in the livers of mice and rats. *Cysticercus pisiformis*, the larval stage of *Taenia pisiformis*, the tapeworm of the dog, is attached to the mesentery of rabbits.

Protozoa which may cause diarrhea and catarrhal enteritis are *Balantidium cavae*, a ciliated protozoan occasionally found in the colon of the guinea pig, and *Trichomonas* spp. and *Giardia* spp., frequently found in the cecum and colon of the hamster.

Salmonellosis

In the absence of an effective vaccine or therapeutic agent for the control of salmonellosis, research workers must rely on strict sanitation and general preventive measures to avoid the introduction and spread of this disease in laboratory animals. Prior to 1954, *Salmonella* spp. were frequently isolated from the organs and feces of the laboratory animals at the National Institutes of Health. In 1954, approximately 38,000 mice were screened and examined for salmonellae by bacteriological examination of composite fecal samples using the procedures outlined by Galton (*2*). In 1956 no salmonellae were isolated from the fecal samples of 2,800 mice, 1,000 rats, 800 guinea pigs, 1,200 rabbits, and 200 hamsters. During the same period in 1956 salmonellae were isolated from 25 monkeys (14.1 percent) of 177 in the colony. In 1957 salmonellosis was not observed in necropsies of more than 4,000 laboratory animals.

That year bacteriological examinations for *Salmonella* spp. were run on 780 samples taken from unopened bags of animal feed and 125 samples of sawdust used by the Animal Production Section. In 375 samples of mouse and rat feed *Salmonella kentucky* (identified by Dr. P. R. Edwards) was isolated from 1 sample; *Escherichia coli* from 7; coliform organisms from 77; paracolon bacilli from 14.

No salmonellae were isolated from 375 samples of the guinea pig and rabbit feed, but *E. coli* was found in 9 samples, coliform organisms in 6, paracolon bacilli in 1.

Organisms isolated from sawdust were *E. coli* from 25 samples, coliform types from 42, and paracolon bacilli from 8.

No organisms were found in samples of heated feed: 9 samples of dog feed, 6 of monkey biscuits, 3 of guinea pig pellets, and 12 of dog chow. These examinations showed that although salmonellae were isolated only once

from the unheated animal feed, fecal contaminated feed and sawdust are possible sources of salmonellosis in an animal colony.

Chronic Respiratory Disease

Chronic respiratory disease, the infection most injurious to laboratory rats, is prevalent in all rat colonies unless disease-free animals have been obtained from outside sources. Early lesions from the naturally occurring disease are seen in 3-month-old rats, and, as the animals get older, the lesions become more extensive.

In most rat colonies approximately 70 percent of the animals past 1 year show rhinitis, middle ear infections, bronchiectasis, and abscesses of the lung. Nelson and King (*3,4*) have reported that infectious catarrh and middle ear infection are caused by pleuropneumonia-like organisms (PPLO) and *Streptobacillus moniliformis*, and that the etiological agent of endemic pneumonia is a filtrable virus (*5*).

In October 1955, we began a long-term experiment to study methods of control and treatment of chronic respiratory disease in rats. Eighteen female and nine male rats were selected from three 60-day-old litters. These animals were divided into 3 groups, each containing 6 females and 3 males. One group was offered chlortetracycline at the rate of 5 mg. per 20 gm. of feed daily; the second group, 5 mg. of sulfamerazine per 20 gm. of feed daily; and the third group, 20 gm. of unmedicated ground feed daily. Necropsies and histopathological examinations were conducted on the original 27 rats and the 5- to 11-month-old progeny through the fifth generation, a total of 175 animals.

At necropsy, the animals in each group were examined for exudates in the nasal passages and middle ears and for involvement of lung lobes. Exudates from the nasal passages, middle ears,

Treatment of chronic respiratory disease in rats

Groups of animals	Number animals	Duration of exposure (months)	Number of animals with lesions		
			Peribronchial infiltration	Bronchiectasis	Areas of consolidation in lungs
Original breeders:					
Control	9	8	5	2	2
Chlortetracycline	9	9	7	0	0
Sulfamerazine	9	8½	7	1	1
F1 generation:					
Control	11	7	9	0	0
Chlortetracycline	12	9	10	0	0
Sulfamerazine	16	9½	3	0	0
F2 generation:					
Control	21	7	9	0	0
Chlortetracycline	13	7	5	0	0
Sulfamerazine	14	7	2	0	0
F3 generation:					
Control	5	6	1	0	0
Chlortetracycline	9	9	1	0	0
Sulfamerazine	5	11	0	0	0
F4 generation:					
Control	7	7	6	0	0
Chlortetracycline	6	6	6	0	0
Sulfamerazine	4	7½	0	0	0
F5 generation:					
Control	7	7½	[1]	0	0
Chlortetracycline	4	7½	[1]	0	0
Sulfamerazine	14	7½	[1]	0	0

[1] Microscopic results not completed.

NOTE: The control group received 20 grams of unmedicated feed daily; the second group received a daily dose of 5 mg. of chlortetracycline per 20 grams of feed, and the third group 5 mg. of sulfamerazine.

and from lung lesions were collected, gram-stained films of exudates were made, serum agar plates were inoculated, and disease-free mice were inoculated with the suspension of the exudates, according to the procedures outlined by Nelson (*5*).

The table shows the results of the necropsy findings from the 27 original animals and their 148 progeny. Each group of the original breeders showed very little improvement from the treatment. The control group contained 2 rats with areas of consolidation and bronchiectasis. In the sulfamerazine group, 1 animal showed bronchiectasis and consolidation of the lung, and the chlortetracycline group contained 7 rats with small areas of bronchiectasis.

The 6- to 11-month old F3 and F4 generation animals, with 9 to 15 rats in each group of the combined generations, showed remarkable improvement. There were no abscesses or areas of consolidation in the lungs of any of the animals. However, in the control and chlortetracycline groups, exudates were present in the nasal passages of 12 rats and in the middle ears of 15 rats. PPLO were isolated from the exudates of the nasal passages of 1 rat and from exudates of the middle ears of 5 in these two groups. No exudates were present in the nasal passages or in the middle ears of the rats fed the sulfamerazine.

In 10 mice inoculated with exudates from the control group of rats, 3 had exudates in the nasal passages and 3 had pneumonia. Of 10 mice inoculated with exudates from the chlortetracycline group, 5 had exudates in the nasal passages, and 3 had pneumonia. The 10 mice exposed to nasal passage and middle ear washings from the sulfamerazine group had no exudates in the nasal passages or middle ears and no gross or microscopic lesions in the lungs. Seven of these mice showed clumps of macrophages in some of the alveoli.

In the F5 generation, the 14 rats in the sulfamerazine group again showed no exudates or lung lesions, while exudates were seen and PPLO were cultured from the nasal passages of the control and chlortetracycline groups of animals.

Histopathological examinations of the lungs of mice that were inoculated with nasal and middle ear washings and emulsions of lung tissue from the three groups of F5 generation rats revealed bronchial pneumonia in each group of mice except those inoculated with washings or tissues from the sulfamerazine group of rats. No gross or microscopic evidence of toxicity or deleterious effects on any of the organs or on reproduction were seen in any of the animals.

In this experiment, sulfamerazine given daily in the feed eliminated rhinitis, middle ear infection, and endemic pneumonia in the 3d, 4th, and 5th generations of rats. Giving the drug at a daily dose rate of 5 mg. in 20 gm. of ground rat feed may be a good, practical way to obtain a rat colony free of chronic respiratory disease.

Other Bacterial and Viral Diseases

Endemic pneumonia, frequent in mouse colonies, is a contagious disease producing high morbidity and mortality. Preliminary tests indicate that the infection may be treated by offering 1.0 mg. of chlortetracycline daily in drinking water.

Epidemic diarrheal disease of suckling mice is of major concern to mouse breeders, since losses from it are as high as 70 percent and the production of mice is markedly reduced. Research workers are often forced to discontinue tests because of outbreaks of infant diarrhea. The disease occurs in mice 2- to 15-days old; older mice and nursing females are immune.

The symptoms, epidemiology, and transmissibility of the disease were reported in 1947 (*6*), and intranuclear and cytoplasmic inclusion bodies in the superficial epithelial cells of the small intestines have been described (*7*). Kraft transmitted infant diarrhea in suckling CFW mice by feeding crude and filtered intestinal contents from infected mice and noted cage-to-cage infections which she attributed to airborne or fly transmission (*8*).

In 1957, we infected 3- to 4-day-old mice through 10 serial passages with oral and intranasal suspensions of intestinal filtrates from mice with infant diarrhea. Ten serial transmissions of the infant diarrhea virus were also made on Chang liver tissue culture media. Infected Chang liver culture fluid from the second passage of the virus produced diarrhea in

7- to 10-day-old mice exposed intranasally. No chemotherapeutic treatment or other preventive measures have been effective in controlling this disease.

Snuffles and mucoid enteritis cause considerable losses of rabbits each year. Snuffles is a highly contagious respiratory disease, reported to be caused by *Pasteurella lepiseptica* and *Haemophilus bronchisepticus*. However, we have been unable to reproduce this disease experimentally in susceptible young rabbits. Chemotherapeutic treatments have been unsuccessful in the treatment of this disease.

Mucoid enteritis, which affects rabbits 5- to 7-weeks old, is responsible for losses up to 70 percent in some colonies. Its cause is unknown, but Templeton (*9*) has attributed it to hereditary or nutritional factors. He reported that chlortetracycline and vitamin B_{12} in feed reduced sickness and losses.

The disease most serious and injurious to guinea pigs is lymphadenitis, caused by streptococci type C. The guinea pig colonies of the Animal Production Section have been free of lymphadenitis since 1954. They were established and expanded from a small group of animals which were kept under strict methods of isolation and sanitation.

Salivary gland disease is a viral disease in guinea pigs recognized by the cytomegalic intranuclear inclusion bodies in the ductal epithelial cells of the submaxillary gland. We have been able to transmit this disease serially in young, pregnant guinea pigs and have produced death and abortion in the experimental animals. However, we have not been able to show that this disease occurring naturally is injurious or causes pregnancy toxemia.

Pregnancy toxemia is thought to be a viral disease of guinea pigs which is recognized by abortion during the latter part of the gestation period and death of the mother during abortion or a day or two after parturition. No treatment is known for it.

Diseases of unknown etiology occurring in laboratory animals are periarteritis in rats, calcium deficiency in guinea pigs, and amyloidosis in hamsters. No methods of control or treatment for these diseases have been reported.

Neoplasms are frequently seen in aged mice, rats, and guinea pigs, but seem to be infrequent in rabbits and hamsters.

Conclusion

The external and internal parasites and the bacterial and viral diseases cause enormous losses of laboratory animals and markedly increase the cost of research. These losses from diseases can be reduced considerably and the number of disease-free animals available for use in forming animal colonies can be markedly increased by good animal husbandry practices and sanitation, and by the development of effective methods of treatment and control.

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After sketching briefly the development of military preventive medicine in the U. S. Army, Dr. Whayne discusses the preventive medicine volumes of the official history of the U. S. Army Medical Department in World War II and points out their usefulness in civilian public health and preventive medicine.

The History of Preventive Medicine in World War II

TOM F. WHAYNE, M.D., Dr.P.H.

WHEN Sir William Osler, soon after the turn of the century, said that preventive medicine is the medicine of tomorrow, he was looking far ahead. He was to live through one world war, and when he died, the year after it ended, it was still regarded as the war to end all wars. He could not foresee the time, a quarter of a century later, when, in the stresses of a global war, all the knowledge of civilian experts in public health and preventive medicine would be pooled with that of medicomilitary experts to make history in these fields at home and in the far corners of the earth.

Modern advances in both military and civilian preventive medicine and public health grew out of the shocking morbidity and mortality of typhoid fever in the Spanish-American War and the challenge of yellow fever and malaria soon afterward. There was close cooperation in those days between Brig. Gen. George M. Sternberg and his group at the Army Medical School and the group on the Johns Hopkins Medical School faculty headed by William H. Welch. The cooperation was so close, in fact, that it would be hard to separate the military and civilian contributions of those years. Fortunately, this is not necessary. There was glory enough for all. Fortunately, too, there were young men like Maj. Walter Reed, who were eager to accept the challenge of the times and to use the new tools, the most useful of which was, and still is, field investigation using epidemiological techniques.

Although preventive medicine still had far to go when World War I began, the developments which had already occurred and the functional organization of resources and personnel accounted for a brilliant record of achievement, seriously marred only by the devastating epidemic of influenza in the fall of 1918. Epidemiological techniques, field investigations, combined epidemiological-laboratory teams for the expeditious evaluation of disease outbreaks and a focal attack upon them, methods developed for the control of the environment—these were far-reaching developments which have solved many a medicomilitary and civilian problem since.

At the beginning of World War II, Brig. Gen. James Stephens Simmons, outstanding in a group of outstanding preventive medicine and public health specialists in the Office of the Army Surgeon General, was selected to plan,

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develop, and administer the Army program in these fields. He was an admirable choice. He had inherited the traditions of Sternberg and Reed. He had served under Gorgas. He was a recognized authority in epidemiology, the laboratory sciences, and tropical medicine. He had worked closely, in an aura of warm personal friendships, with civilian experts in his own and other fields.

General Simmons was one of the somewhat limited group who appreciated from the beginning the global nature of World War II. He built up a flexible, practical, and highly effective military organization. He had the foresight to plan a medical intelligence organization which provided essential, global information on health hazards and conditions. His greatest contribution, however, was the forging of civilian and military experts into a homogeneous, cordial, and productive working relationship. The stimulus thus provided for cooperative endeavors was among the most precious commodities to come out of the war. By their joint efforts, these groups solved medical problems in environments ranging from the Arctic to the tropical lands of Africa and the far islands of the Pacific. The Army Epidemiological Board and the United States of America Typhus Commission, whose published reports fill a 3-foot shelf, were General Simmons' concept.

History of World War II

Medical military history, in the formalized modern sense, began with the publication, only 2 years after the end of hostilities, of the story of the Crimean War. This history was written because Andrew Smith, director general of the British Army Medical Service, found himself, on assuming his task, with "a complete absence of all details of previous wars calculated to instruct," and he determined that no successor of his should ever again find himself in that situation. In spite of the wide differences in the circumstances of the two wars, these volumes on the Crimean War, as Surgeon Joseph J. Woodward said, "gave direction" to the efforts of the U. S. Army Medical Department in the Civil War. Brig. Gen. Frank W. Weed, editor in chief of the Medical Department history of World War I, wrote later that if there had existed during the Civil War a dependable record of earlier wars in this country, epidemics might have been foreseen, even in those pre-epidemiology days, and diarrheas prevented.

The volumes that make up the series entitled "Medical Department, United States Army, in World War II" are part of a total series of about 125 (proposed) volumes dealing with all aspects of the war in all theaters in which it was fought. The Medical Department series will eventually consist of about 50 volumes. One volume, in the surgical series, was published in 1952. Since the fall of 1955, there also have been published, exclusive of the preventive medicine volumes, 1 (of 8 scheduled) administrative volume; 6 (of 15 scheduled) surgical volumes; and a dental volume and a volume on cold injury (in a series of 8 scheduled volumes on various other subjects). It is hoped that all the medical volumes can be completed by the end of 1961.

Preventive Medicine Volumes

When the preventive medicine series of this history was planned, General Simmons was selected as chairman of the advisory editorial board, a position which he filled brilliantly until his death in 1954. His work was then taken over by Brig. Gen. Stanhope Bayne-Jones (Ret.), who has served with equal wisdom and competence.

The advisory editorial board set up under General Simmons consists of men distinguished in the field of preventive medicine, all of whom were in service, in positions of responsibility, at home or overseas. They developed the outline for the history and selected the authors and reviewers for the various chapters. With great wisdom, they selected the authors from among men who had "been there," who understood administrative and other military problems as well as epidemiological and other preventive medicine problems, and who could relate both to the environment in which these problems arose.

Of the 8 volumes proposed in this series, 3 have already been published. One dealing with environmental hygiene and another with personal health measures and immunization were published in 1955. One of the three vol-

umes on communicable diseases was published in 1958; another will appear in 1959. The remaining volumes will cover the organization and operation of the program; malaria and other anthropod-borne diseases; civil health problems; and education, laboratories, and training.

The volume on environmental hygiene relates how sanitarians, entomologists, engineers, and physicians maintained standards of sanitation in areas of endemic disease and in the midst of destroyed water and waste disposal systems, or how they set up these systems in areas in which they had never existed. The subjects covered include food management, housing, water purification, waste disposal, insect control, rodent control, the research background of these programs, foreign quarantine, and preventive medicine in ports of embarkation and for persons in transit.

The story told in this book is impressive. Plague was not reported in U. S. Army personnel during the war. No plague-infecting rodent was recovered from a United States military vessel or aircraft. Only 13 cases of cholera were reported during the whole war, and only 102 cases of louseborne typhus, only 1 of which was fatal. There were no cases of yellow fever.

Subjects covered in the volume on personal health measures and immunization include the selection of manpower and the lessons learned from the physical and mental defects thus revealed, personal hygiene, clothing, malnutrition and deficiency diseases, preventive psychiatry, accidental trauma, and the Army immunization program. The tetanus program is typical of the success of many of these measures. Only 12 cases were recorded in the whole Army, and 6 of these were in personnel who had never been immunized.

During World War II, almost 33,000 deaths overseas were caused by nonbattle injuries. More realistically, nonbattle trauma was the cause of 1 in every 5 notifications of death sent to the family of a United States soldier. This is a problem which has existed since the Revolutionary War and which has increased in gravity as mechanization of the Armed Forces has increased. It is also, as a British military ophthalmologist forthrightly put it, augmented by "the stupidities of fools." As the war ended, it was outstandingly demonstrated that there was need for military and civilian organizations in many fields to combine their efforts for the solution of what is a major public health as well as a major military problem.

The first of the volumes on communicable diseases to be published concerns diseases transmitted through the respiratory and alimentary tracts. It begins with an excellent chapter on modes of transmission and then discusses special diseases and disease groups.

Interesting comparisons can be made between the diseases discussed in this volume and those discussed in the World War I history. The slight discussion of amebiasis in the World War I history and the extended discussion in this volume, for instance, indicate not only the importance of this disease at this time but also the greatly increased knowledge concerning it.

Tuberculosis was a major problem in World War I, when X-ray techniques were crude by modern standards and screening was chiefly characterized by good intentions. Patients from World War I are still part of the population of Veterans Administration hospitals. In World War II, the efficient screening and casefinding methods which had been developed between the wars were put to good use. The Military Government Organization undertook the control of tuberculosis as one of its first functions during the period of occupation, rightly regarding the restoration of normal casefinding and reporting practices as quite as

Availability of Volumes

Upon publication the preventive medicine volumes in the history of the Medical Department, United States Army, in World War II are placed on sale by the Superintendent of Documents, Government Printing Office, Washington 25, D. C. The following are now available:

Environmental Hygiene, vol. 2, 1955, 404 pp., $3.50.

Personal Health Measures and Immunization, vol. 3, 1955, 394 pp., $3.25.

Communicable Disease, vol. 4, 1958, 544 pp., $5.50.

important as the provision of beds for tuberculous patients. Research during the war also produced valuable information on two subjects. One was the inherent risk of small lesions whose activity is difficult to determine. The other was the causes of breakdown from tuberculosis, including the types of stress which lead to relapse and those which can be withstood without the breakdown of a latent lesion.

Historically, meningococcal meningitis has always been a disease of serious concern to workers in both civilian and military preventive medicine. Across the years, whatever progress has been made in prevention and treatment in one field has been quickly applied in the other. Both civilian and military experts worked on this disease in World War II. Sulfadiazine, used prophylactically, was reasonably effective in the military organization, but prevention in a heterogeneous and nonregimented civilian population was—and still is—impractical. Treatment, in spite of modern advances, is still far from satisfactory. The situation in World War II was improved over World War I. Although this disease ranked 76th in admissions to Army hospitals in the first world war, it was the 6th ranking cause of death because 40 percent of the cases were fatal. Civilian and military experts must continue to pool their efforts if the disease is to be controlled.

Use of Preventive Medicine Volumes

The volumes in the preventive medicine series are not a chronological record of events. Their primary objective is a searching evaluation of military preventive medicine in a global war. They tell the engrossing story of attempts to control diseases, modify environments, and maintain the health of military and civilian populations under wartime conditions in a conflict that covered the earth. Some diseases had never before been recognized. Every new environment offered new potential threats. The very water the troops drank and the rivers in which they bathed were hazards. As always happens, our knowledge of the natural history of disease and of human ecology in its broadest perspective was increased by these wartime experiences.

The principles and practices of preventive medicine and public health had to be applied to young and healthy men in military service, and they also had to be applied to large civilian populations of all ages and races and of both sexes. In liberated and occupied countries, this was the responsibility of the Civil Affairs and Military Government Organization. The prevention of disease and the control of environmental factors were accomplished rapidly and efficiently because of military-civilian teamwork. The principles and practices of military preventive medicine and of civilian public health often overlap, but they are fundamentally the same, even when the local population and environment to which they must be applied are different.

Reviewers of the volumes of the preventive medicine series have shown great appreciation of their objectives as well as of the methods by which these objectives have been attained. Among the points they make are these:

1. As these books show, preventive medicine is a comprehensive discipline, which encompasses far more than environmental sanitation and the control of communicable diseases.

2. In these books, the source material is so distilled that the reader who could not possibly digest it in the mass need concern himself only with the essence. They are packed with factual data, including comprehensive and extremely useful statistical data. They also frankly confess errors.

3. These are very readable books. Says a British reviewer, "Our American cousins have good reason to be proud." Says an American reviewer, who was undoubtedly in service himself, these volumes are recommended to "those hopefully still vigorous spirits who might enjoy just reminiscing," a point which reviewers of other volumes in the series have also emphasized.

4. The material is applicable to many areas of civilian public health and preventive medicine. These volumes contain much for such specialists as the sanitary engineer and the sanitarian, the entomologist, the industrial hygienist and others in industrial practice, the veterinarian, the nutritionist, and the public health nurse. They should also be of interest and profit to the organizations, institutions, and agencies in which these specialists work,

including both official and voluntary health agencies, medical schools and schools of public health, research institutions, hospitals, medical departments of commercial firms and factories, and national and international health agencies outside the United States.

Practicing physicians today must have a broad understanding of all aspects of the prevention of disease and of the influence of the physical and social environment upon their patients. They too will find these books useful.

Finally, civil defense organizations require a specific knowledge of emergency health programs which are applicable upon a mass basis. The preventive medicine story of World War II as it is recorded in these volumes is the basis of much of the medicine of the future, in which medicomilitary and civilian cooperation will be necessary for the protection and maintenance of health under conditions which invite disease and trauma.

It takes more than the mere existence of a medical military history to make such a history useful. The value of the Civil War history was never fully realized because it was distributed on an individual basis, through members of the Congress. The distribution of the World War I medical history was considerably more logical, but it was scarcely publicized, and we paid dearly for the oversight in World War II, when the majority of medical officers were almost completely ignorant of what had been done in World War I both in their special fields and in the general medicomilitary field. As I have helped to prepare the medical history of World War II, I have had many occasions, for comparative purposes, to refer to the World War I history, and, to my chagrin, I have often found in these volumes the plain and clear answers to many of the problems over which I and my associates struggled in World War II. It would pay all of us to remember another saying of Sir William Osler's, that by the historical method alone can many of the problems of medicine be approached most profitably.

Conclusions

Since the end of World War II, there has been a dramatic decline in the extent and severity of many diseases of public health and military significance. Malaria, for instance, by a continuation of the wartime lessons, is in a fair way to being tamed and even eradicated in most of the world within the near future. This is also true of other diseases. But the work is far from done, and those responsible for progress in preventive medicine and public health in civil life may profit greatly by studying the experiences of military men in World War II. In the volumes devoted to preventive medicine in the official history of the U. S. Army Medical Department are set forth methods, techniques, and basic philosophy as they are applicable to civilian public health and preventive medicine of today and even of tomorrow.

PHS Cancer Chemotherapy Project Matures

The Public Health Service's cancer chemotherapy program, mobilizing resources of hospitals, universities, research laboratories, industry, and government, has steadily expanded over the last 5 years with the following results:

- More than 40,000 compounds and other materials are being tested annually on more than a million mice to uncover chemicals with anticancer properties. About 70,000 materials have been screened.
- Between 400 and 600 materials a year are promising enough to be further analyzed with tests in mice and larger animals. Nine out of 10 materials are rejected as either ineffective or too toxic.
- About 40 materials a year are approved for clinical trials with human patients. Currently 70 are undergoing clinical trials.

Although incidence of poliomyelitis in this relatively isolated community of western Montana has been considerably lower than in more densely populated urban areas, the epidemiological characteristics of the disease have remained unchanged.

Naturally Occurring Poliomyelitis Antibody in Hamilton, Montana

ROBERT K. GERLOFF, M.A., CARL L. LARSON, M.D., and LILLIAN R. B. GLESNE

SEROLOGIC SURVEYS have been useful for epidemiological study of many diseases, detection of their occurrences in communities, and determination of the immune status of populations to such diseases. They have been especially applicable to studies of poliomyelitis, and, for this particular disease, have been greatly enhanced by the development of simplified, tissue-culture tests for neutralizing antibody. Among the more extensive poliomyelitis investigations in the United States is the one of Melnick and his associates (*1*) made in Charleston, S. C., and Phoenix, Ariz. Fox and his associates (*2*) have thoroughly studied three communities in Louisiana.

The survey reported here was conducted in a rural community in western Montana. Data portraying incidence of poliomyelitis antibody in this area emphasize particularly the relationship between age and prevalence of antibody, relationship between age and antibody titer, and intrafamilial spread of poliovirus.

General Procedure

The community studied was Hamilton, Mont., and its environs of approximately 24 square miles. Population of this area is about 5,500, of which 75 percent reside in the town itself. Mountainous terrain, practically without settlement, extends 75 miles east, 100 miles south, and 125 miles west from the study area. U. S. Highway 93 passes through Hamilton in a north-south direction; a spur busline connects it with transcontinental transportation at Missoula, 50 miles north. In contrast to many densely populated Atlantic and Pacific coastal areas, this community is relatively isolated with respect to geographic setting and proximity to main commercial routes of travel.

Through cooperation of the four schools in the area, 1,034 blood samples were collected in February 1955 for serologic study. Most were from children in grades 1 through 12, but 138 were from adults and 50 were from preschool children. Specimens were obtained from 94 percent of the pupils in the three elementary schools and from 76 percent in the high school. Brief histories, including age and location of residence, were obtained from all participants. Presumably, none of them had received poliomyelitis vaccine, since commercial vaccine was

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not yet available and experimental vaccine had not been tested in this area. Serums were classified according to age of the donor (table 1); age 6–7, for example, signified any age from 72 months through the day preceding the eighth birthday. Children less than 6 years old were grouped as preschool children, and persons 21 years or older were grouped as adults.

Laboratory Procedures

Serums were frozen at −24° C. until tested for poliomyelitis neutralizing antibody. A metabolic inhibition test, similar to one described by Salk and co-workers (*3*), was employed. All serums were tested in twofold dilutions, 1:8 through 1:1,024. Serums with 1:8 or higher titer were designated seropositive. Those with titer of 1:1,024 might have been positive also in higher dilutions, if such dilutions had been tested.

Age and Incidence

With a few exceptions, incidence of antibody to a specific type of poliovirus or to a combination of types gradually increased as age of the subjects increased (table 1). The greatest deviation from this trend occurred with respect to type 2 antibody, which was found in 48 percent of children aged 14–15, but in a considerably smaller percentage of children immediately older or younger.

There was no evidence that poliovirus either had recently entered the community or had been present several years before and then disappeared, leaving only older persons immune. In all age groups, type 2 antibody was more prevalent than type 3; in all except the 12–13 and 14–15 age groups, type 1 antibody was more prevalent than either type 2 or type 3. Among preschool children, 51 percent possessed one or more types of antibody, and the percentage gradually increased by age groups to 96 percent in adults. However, only 2 percent of preschool children, about 5 percent of high school students, and 20 percent of adults had all three types of antibody.

Age and Antibody Titer

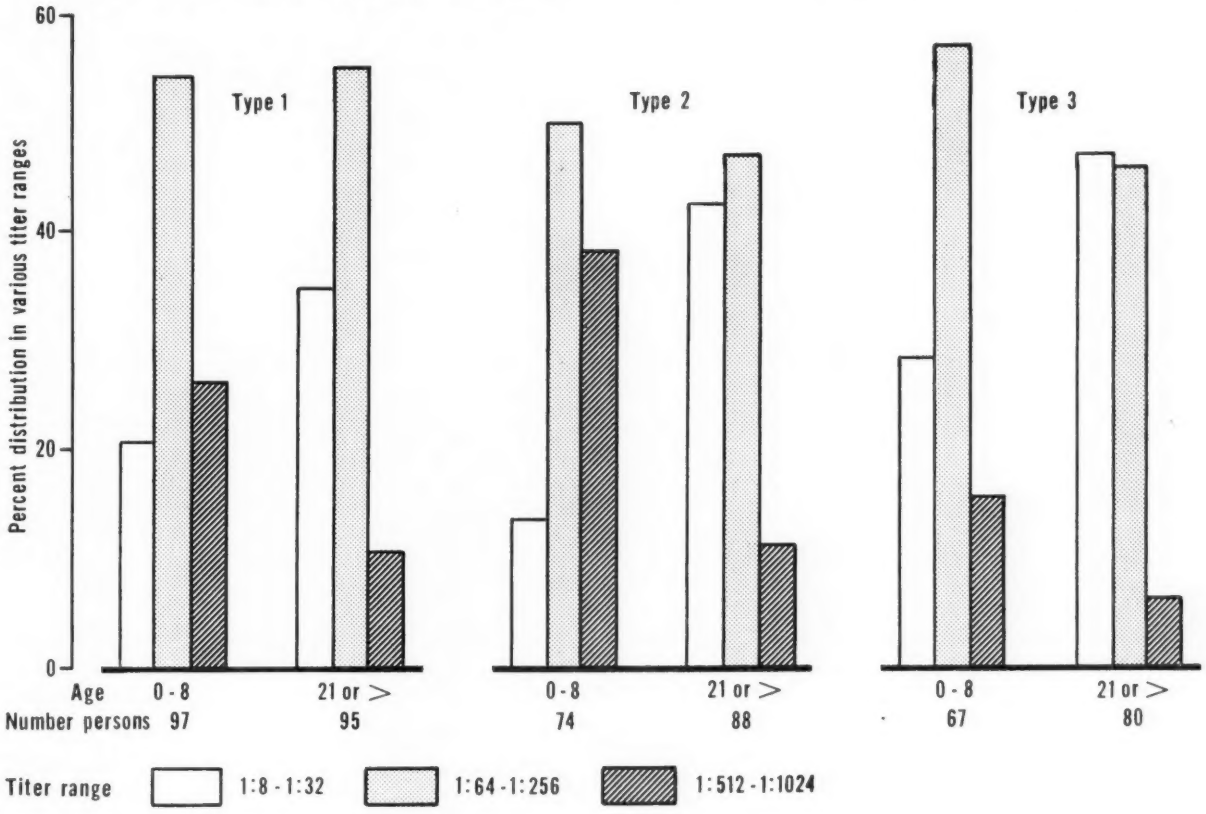
Seropositive serums from the adults and from children through 8 years of age were compared on a basis of antibody titers to the three polioviruses. This age range of children was selected so that numbers of seropositive serums from them and from the adult group would be similar. Type 1 antibody occurred in 97 of the 276 children and in 95 of the 138 adults (see chart). Whereas 21 percent of the children and 35 percent of the adults had titers in the 1:8 to 1:32 range, 26 percent and 10 percent, respectively, had titers in the 1:512 to 1:1,024 range. Almost equal percentages had titers in the intermediate range of 1:64 to 1:256. Titers of antibody to the other polioviruses in the two age groups were similarly

Table 1. Distribution of poliomyelitis antibody in a population sample of 1,034 persons, Hamilton, Mont., by age group and poliovirus type

Age (years)	Number of persons in group	Percent seropositive against—				
		Type 1	Type 2	Type 3	All 3 types	One or more types
Under 6 (preschool)	50	31	14	12	2	51
6–7	141	33	28	24	3	61
8–9	[1] 152	39	33	28	6	67
10–11	155	37	36	34	7	68
12–13	157	37	37	33	7	70
14–15	130	44	48	35	4	80
16–17	111	53	38	36	6	85
21 or over (adults)	138	69	64	58	20	96

[1] With reference to the chart, 85 children in this group were 8 years old.

Relationship between age and poliomyelitis antibody titer in persons who were seropositive.



compared. However, because the same type or types of antibody did not occur in all persons, the composition of the groups included in the second and third analyses varied somewhat from that of the first.

Regardless of antibody type, more high titers were found in seropositive children than in seropositive adults. Differences were greatest in the type 2 analysis where only 11 percent of adults had titers in the high range as compared with 38 percent of children.

Intrafamilial Spread of Poliovirus

Serums from all children were grouped according to families (table 2). The extent to which poliovirus spreads within a family following its introduction by one or more carriers was studied by examining the degree of similarity in seroimmune patterns of children within each family. Each of the three types of poliovirus was considered a distinct disease entity, capable of invading a family independently of the other two types. Each family, therefore, represented three family-type combinations. If, for example, the two children in a particular family both possessed type 1 antibody, neither had type 2, and only one had type 3, two of the combinations were said to be in agreement, but the third, in disagreement.

Of the 468 combinations represented by families with two children, 87 percent were in agreement and 13 percent were in disagreement. The analysis was continued to determine how many instances of disagreement could be explained on the basis of age difference. If the child possessing antibody was the older, perhaps he had acquired the antibody through natural infection before the younger child was born. Sixty-six percent of the instances of disagreement could be accounted for in this manner. As a final figure, 96 percent of the combinations represented by families with two children gave either perfect agreement or disagreement which might be explained by order of birth. Comparable final figures for families with 3 or 4 children were 90 and 79 percent,

Table 2. Common occurrence of poliomyelitis antibody in multiple children of individual families

Children per family	Number of families	Number of family-type combinations [1]	Percent of family-type combinations—	
			With perfect agreement in antibody pattern [2]	With perfect agreement or explainable [3]
2	156	468	87	96
3	64	192	71	90
4	19	57	63	79
5	4	12	92	----

[1] See text for explanation.
[2] Antibody of a specific type either present in all children or absent in all.
[3] Explainable on the basis of order of birth of multiple children in a family.

respectively. Only 4 families with 5 children were available for study, but 92 percent of the combinations represented by them gave perfect agreement.

Complement Fixation Studies

Complement fixation tests on 225 serums, representing a sample of approximately 40 percent of the children in the age group 0–12, were performed by Dr. David B. Lackman of this laboratory. Unheated antigens were used throughout. The percentages of the group possessing types 1, 2, and 3 neutralizing antibody were, respectively, 44, 37, and 25, while those with complement-fixing antibody were 7, 16, and 12.

Discussion

The three principal conclusions from these data, namely, that prevalence of poliomyelitis antibody in people of this community is directly related to their age, that children generally have higher antibody titers than adults, and that intrafamilial contact rapidly disseminates poliovirus, agree with conclusions of other investigators who have studied entirely different communities, most of which have been urban. During the past 18 years, type 1 has apparently been the most common type of poliovirus in this community, type 3 has been the least common, and type 2 has been intermediate. This relationship in prevalence of the three types also exists in other areas of Montana (*4*). The high incidence of type 2 antibody in the 14–15 year age group, as compared with older or younger children, probably reflects past invasion of one particular classroom by type 2 virus.

Rate of acquisition of poliomyelitis antibody with increasing age appears lower in this community than in many other parts of the United States and is definitely lower than that in many other parts of the world. However, differences in methods of testing serums, including variations in the lowest serum dilution tested, complicate direct comparison of results reported by different laboratories. In the current investigation, only 6 percent of children 16–17 years old possessed all three types of antibody. Identical results have been reported from Swiss children aged 18–19 (*5*). In contrast, 40 percent of 5-year-old children in urban areas of Gothenburg, Sweden (*6*), and 75 percent of children 3 to 4 years old and more than 90 percent of children aged 7–9 in families of low socioeconomic class in Peru and Colombia (*7*) possess all three types of antibody. Poliovirus apparently spreads in people of western Montana at a rate similar to that in the higher socioeconomic class of people in Charleston, S. C., but at a much slower rate than in this class of Phoenix, Ariz., or in the lower socioeconomic class of either city (*1*). Poliovirus also spreads much more slowly in this Montana community than in three urban and semirural communities of Louisiana (*2*).

Slow dissemination of poliovirus in this area is probably due to an interplay of many environmental factors. The community is well separated from others. Many children go to and from school in private buses, but there are no public conveyances. Since there are no private schools, all children attend the same public schools. Streets are wide, homes are relatively far apart, and most homes have ample space for the occupants. Nearly all homes have indoor sanitary facilities. Although many families have private wells for water supply and nearby septic tanks for sewage disposal, necessity for such utilities is not restricted to any particular socioeconomic class. During many months of the year, human carriers of

poliovirus apparently are nonexistent in the community, as noted in an unpublished sewage study by C. L. Larson and his associates.

Because socioeconomic differences in the community are minimal and have little relationship to factors ordinarily considered of public health significance, the correlation between incidence of antibody and socioeconomic status was not thoroughly studied. The older north and newer south sections of the town of Hamilton were compared, however. In the south section, where the average family is generally considered to be somewhat above that of the north in income, cleanliness, and education, 41 percent of 217 children were without antibody to any type of poliovirus. In the north section, 20 percent of 192 children were in a similar condition.

Since high titers were found more frequently in children than in adults, they appear more likely to result from recent initial infections than from continued reexposure throughout life. Melnick and his associates (*8*) derived the same conclusion from complement fixation tests of human serums collected in Cairo, Egypt. Because poliomyelitis complement-fixing antibody, which is of relatively short duration in the blood, was confined almost entirely to childhood, re-infections in older persons were assumed to be rare. Le Bouvier (*9*) likewise concluded from data on Cairo residents that poliomyelitis antibody tends either to be absent from children or to exist in high titer, while in adults many medium or low titers are intermingled, due to gradual diminution of titers with age.

The data on seroimmune patterns of multiple children within the same families (table 2) augment other information (*10,11*) on the importance of intrafamilial contact in spread of poliovirus.

Since complement fixation tests were performed on serums from children of a rather narrow age span, results are of limited value. Ratios of percentage of children possessing neutralizing antibody to percentage possessing complement-fixing antibody were 6.3, 2.3, and 2.1 for types 1, 2, and 3 antibody, respectively. Because poliomyelitis complement-fixing antibody disappears much more rapidly than neutralizing antibody, these data would indicate that types 2 and 3 poliovirus had invaded children 0–12 years old more recently than had type 1.

Summary

Incidence of poliomyelitis antibody resulting from natural infection in a relatively isolated rural community of western Montana was determined by tests of 1,034 serums collected from residents, mostly children, in and near the town of Hamilton. Neutralizing antibody to all three types of poliovirus was present, but in nearly all age groups type 1 antibody was the most prevalent and type 3 the least prevalent. Incidence of antibody generally increased with increasing age of the population, but spread of poliovirus has been much slower in this community than in densely populated areas. Only 5 percent of the high school pupils, aged 14–17, had been infected by all three types of virus. High antibody titers occurred more frequently in children than in adults. Multiple children in individual families were, in most instances, either all immune or all nonimmune to a particular type of virus, a fact which portrays the importance of household contact in spread of poliovirus through a community.

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New Simplified Germ-Free Laboratory

The possibility that germ-free animals may be used for experiment in small laboratories of health departments and universities may be sped by the outcome of field tests of a device which has been demonstrated successfully at the University of Michigan. The cabinet was designed by Dr. Richard Horton, now with the National Institute of Allergy and Infectious Diseases of the Public Health Service.

Similar units are being made available to several institutions for field trials, some to be tested by experienced investigators and others to be tested by men with no previous experience with germ-free techniques.

Although germ-free laboratories have been operated successfully at Notre Dame University, Walter Reed Army Medical Center, and the National Institutes of Health, the cabinet designed by Dr. Horton is intended to function on a relatively simple and economical scale.

The apparatus, a sealed box of glass and metal, is about the size of a frozen food cabinet. Investigators reach into the sterile area through sealed-in rubber gauntlets. A pressure compartment at one end sterilizes all food and equipment by steam before it enters the living quarters of the germ-free animals. All air introduced into the cabinet is heated to 750° F. and is then cooled before it passes into the chamber. Excess food and feces have remained in the box for months without odor or signs of decomposition.

Dr. Gerald Abrams, Michigan pathologist, who tested the machine with guinea pigs delivered into the cabinet by sterile cesarean section, believes the device is also virus proof, but he has not yet tested that hypothesis.

STATEMENT

Conference of Municipal Public Health Engineers on air pollution control, October 6, 1958

Responsibilities of Local Health Agencies for Air Pollution Control

ACUTE effects on health, resulting in death, attributable to gross air pollution exposures of masses of people have been recognized and reported. More recently studies have suggested subclinical effects which may develop into chronic and acute biological damage upon prolonged exposure to moderate amounts of air pollution. As society advances, conditions which impede attainment of the maximum of physical and mental well-being are considered detrimental to health. Thus, air pollution which interferes with food consumption, water intake, sleep, relaxation, and recreation or which creates physical or mental stress is recognized as impairing health. In the past few decades concern with air pollution has changed considerably from primarily problems of smoke and fly ash to problems involving toxic and noxious fumes, gases, and dusts as well.

While the exact nature of various interactions of air pollutants has yet to be determined precisely, public interest in air pollution continues to increase. Consequently, each year additional local health officers and public administrators must face these questions: Should an air pollution control program be started in this community? and, if so, What should be the role of the local health department? This statement will not attempt to answer these questions; rather it is intended to focus attention on factors to be considered.

Public health administrators will find it is easy to adhere to the general thesis that air pollution control is best accomplished at the lowest level of government capable of effective action. Because air pollution control involves localized as well as area problems basic activities are required at the lowest level capable of supporting the program needed. In the absence of precise tolerance limits for aerial contamination, local citizens' opinions of relative values tend to set the standards for community acceptability. Such standards may frequently be qualitative rather than quantitative, and should consider not only health and well-being but also damage and deterioration to property, interference with use of homes, businesses, or recreational facilities, and hazard to air and ground transportation. Thus each area must define its own need for air pollution control and determine the extent to which it will support such activities. Evaluation of need for air pollution control is facilitated by an inventory of sources, supplemented by strategic sampling and a recognition of other factors peculiar to the community.

It is not the purpose of this statement to advance public health agencies as the only logical administrative units to direct air pollution control programs. However, health departments do possess many valuable resources and skills useful to such activities. Furthermore, public health officials must exercise more interest in air quality if they are to satisfy the total health needs of the people they serve. Therefore, this statement will attempt to outline in an objective way the contributions that public health has to offer air pollution control.

There are several possible roles for a local health agency. The health department may be assigned direct, primary, and sole responsibility for air pollution control. It may provide advisory, consultative, or staff services if another agency is directly responsible. In some circumstances, responsibility may be split

Committee Members

Members of the Committee on Air Pollution Control of the Conference of Municipal Public Health Engineers which formulated this statement were P. W. Purdom, director, division of air pollution control and environmental sanitation, Department of Public Health, Philadelphia, chairman; Eric W. Mood, director, bureau of environmental sanitation, Department of Public Health, New Haven, Conn.; and Charles L. Senn, director, sanitation division, Los Angeles City Health Department.

Also members were John W. Lemon, administrator, Fulton County Health Department, Atlanta, Ga.; Charles M. Copley, Jr., deputy health commissioner, environmental sanitation services, St. Louis Health Division, St. Louis; Wilmer H. Schulze, assistant commissioner of health, sanitary section, Baltimore City Health Department; and Stanley B. Stolz, public health engineer, Department of Public Health, New Rochelle, N. Y.

between two departments, one primarily a smoke abatement unit and the other the health department with responsibility for controlling odors and gaseous emissions.

Split jurisdiction does not readily permit unified planning of a total program and provides an opportunity for some problems to fall between the two agencies with resulting neglect or duplication. This type of administrative arrangement is so awkward that it is not recommended and, consequently, will not be discussed further.

Factors in Assigning Responsibility

There are many bases for deciding which unit of government should be assigned responsibility for air pollution control. It is true that the best selection depends on the local situation, but this statement alone does not offer any guide to an objective administrator. There are several criteria which may be used to ascertain the feasibility and appropriateness of assigning responsibility to any unit.

Perhaps the most important factors are the degree of emphasis which the community desires to place on this activity and the extent it is willing to support air pollution control through appropriation of funds. In the Los Angeles County Air Pollution Control District, where appropriations have ranged around $4 million annually, or about 50 cents per capita, it was only reasonable to establish an independent agency with air pollution control as its sole objective. In areas where local stresses have not been so great, there have been advantages in utilizing the administrative structure and other resources of existing agencies.

Where there is a choice to be made between two or more agencies, an objective analysis should consider these factors:

- Adequate administrative direction.
- Capability of the unit to provide, or acquire, the necessary requisites for the service.
- Possession of a staff of trained personnel adaptable to air pollution control work.
- Willingness of the unit selected to give to the activity the emphasis desired by the public.
- Availability of laboratory facilities.
- Benefits accruing from coordination with related activities.
- Public attitude.

From the perspective of these factors, it is readily apparent that health agencies have a great deal to offer to an air pollution control program.

Most health departments have established divisions that are principally concerned with the elements of the environment that affect health—pure food and water, a safe and healthy home, work, and recreational environment, and sanitary waste disposal. The air supply naturally must be considered in association with these other environmental fundamentals vital to life.

Where air pollution control is a responsibility of the health agency, it has been found to be advantageous to the agency's other responsibilities. Sanitarians in their recommendations for the ventilation of food establishments consider the problem of cooking odors. Industrial hygiene proposals for protecting workers inside the plant are coordinated with air pollution control requirements to prevent the uncontrolled venting of noxious fumes, gases, and dusts to the atmosphere. Disposal of waste products, whether liquid, solid, or gas, can be considered from an overall point of view. Laboratories used for industrial hygiene and

other purposes can also serve the air pollution control activity.

Health departments are equipped with personnel and facilities for public education, a most important aspect of an air pollution control program. Also, they have physicians who are experienced in medical epidemiology and who can analyze the data available and establish the proper correlation between community health and air pollution. Not the least asset is the public health administrator's orientation to stress prevention.

These advantages are attested, according to a 1956 survey, by the fact that the health department was responsible for air pollution control more often than any other single type of agency (*1*). This is not to belittle the very fine work of units in other departments. In fact, where smoke abatement is the major concern, there may be logical reasons to locate the activity elsewhere than in the health department. However, as a total approach to air pollution control evolves, it seems to have a greater affinity to health agencies or independent units.

The health officer is cautioned that he should not rush into an air sanitation program if he is not prepared to follow through with a total program, one that will attack nuisance problems of smoke, dust, and offensive odors as well as those pollutants whose association with specific biological responses is more readily proved. He must be prepared to give budget support and emphasis to the program to the extent of public demand. And he should add to his staff the chemical and mechanical engineers and other personnel necessary to service competently the community's needs.

Services Provided by Control Unit

Since ability to give the service desired is one of the most important factors in deciding what duties to assign an agency, the services provided by an air pollution control unit should be reviewed.

One basic activity inherent in practically all programs dealing with the environment is the observation and investigation of conditions in the field. Complaints are frequently the initial cause for the action, and many communities are content to measure the effectiveness of a program by the absence of complaints. Complaints rest upon such tenuous factors as emotional reactions, social standards, past history, and vested interest that their usefulness is of a limited nature. To be sure that the community maintains the quality of air desired requires continuing self-initiated observation and surveillance. This immediately creates a need for standards for evaluation. The general purpose of the community's air pollution control program and the conditions of pollution which the community will not tolerate should be stated in a basic law adopted by its legislative body. These premises are usually amplified by more detailed standards and regulations promulgated by a designated rule-making body. With written criteria of this type it is possible to make objective field evaluations and initiate needed corrective actions uniformly and fairly.

Sighting smoke and dust and smelling odors is basic to most programs in correcting the most offensive gross pollution. It will soon become apparent, however, that treatment after illness is not the way to run an air pollution control program. Prevention, as in any other public health program, is the keynote of air pollution control. The chief preventive tool utilized is the review and approval of plans for new installations and major alterations or modifications of existing heating and processing equipment and related control devices.

Approval of plans leads logically to performance testing after an installation is complete. Such testing is also applied to existing installations to determine the extent to which they comply with legal standards for controlling emissions. Testing of stack emissions may be done by the governmental agency itself or under its supervision by the company in question, or by a consultant to either the agency or company. Engineering surveys of sources of emission help to determine where such tests will be most helpful.

Consideration should be given to air pollution in community planning, development, and redevelopment. There should also be some activity directed toward determining what is happening to the community's air supply on an overall and long-range basis. This involves sampling the air for analysis and correlating sample data with meteorologic factors and other conditions.

Atmospheric sampling and stack testing require the availability of laboratory services. The larger health departments frequently have laboratories serving industrial hygiene and sanitary engineering activities which can be adapted for air analyses. Also, many smaller local units use facilities made available through the cooperation of State health departments and other agencies. In some instances laboratory service is obtained by contract with an educational institution or private facility.

Personnel

The need for personnel is more directly related to the character of the community and the emphasis and quantity of services desired than to population and area served.

If inspections and observations are made, various types of personnel can be trained to do the work. However, if instruction in appropriate fuel-firing methods for heating equipment is also to be given, then personnel with practical experience as stationary engineers are required. In persons who evaluate and give advice regarding problems of dust, fumes, and gases, and who review plans, appropriate mechanical and chemical engineering training and air pollution control experience are desired assets. Laboratory work and sampling require either chemists or chemical engineers. All the various services require clerical assistance.

It can readily be seen that the smallest health units can afford few of these services other than provision of local observation and inspection. If the unit is so fortunate as to have an engineer on its staff, it can undertake other services. Lacking one, it will have to rely on State assistance for technical and laboratory services.

To establish a semi-independent, full-time air pollution control service would seem to require a minimum of three persons, an engineer-director, a clerk, and a chemist. In some circumstances, some agencies might prefer an "operating engineer" type of inspector instead of a chemist. This decision might depend on the background of the engineer-director.

Such a service, under 1958 economic conditions, would require an annual budget of at least $15,000 to $20,000. This would mean an expenditure of 15 to 20 cents per capita for a community of 100,000 population. Therefore, it is unlikely that very many communities of less than 100,000 population will want to establish semi-independent, full-time units. Larger units can seldom operate a program on less than 5 cents per capita, while 10 to 15 cents is more likely, and some spend from 30 to 50 cents per capita.

Even a unit with the minimum staff indicated will require some assistance from the State agency on more complex and unusual problems. It would probably be unwise for a health officer to assume responsibility for air pollution control without assurance of budget support for at least the minimum staff indicated, unless there is ample assistance in quality and quantity of personnel and facilities from the State agency for the necessary technical and analytical work.

Role of Local Health Department

Now that criteria for establishment and assignment of the air pollution control functions have been reviewed, as well as the services provided and staff required, it is possible to consider objectively a more precise definition of the role to be exercised by the local health agency. The health department either may be primarily responsible for the administration of the program, or it may serve in an advisory and consultative capacity.

It appears self-evident that the health agency must be considered and consulted, even in situations where it does not have the primary responsibility. The health department has a previously established concern with the ventilation of food establishments, maintenance of acceptable atmosphere in industrial and other work areas, and standards for the storage and disposal of wastes, particularly contaminated wastes such as those of clinics and hospitals.

The impact of air pollution control regulations on these matters and the impact of health department activities on air pollution should be considered by both the health department and the air pollution control agency. Joint consideration of proposed changes in standards appears essential. A mechanism for joint review of plans under which one agency would

not grant approval without consent of the other is desirable.

In some circumstances, the health department may have established laboratory facilities for industrial hygiene and sanitary engineering. Such facilities could be used by the air pollution control unit to avoid the necessity of building a new laboratory. The health department then would serve as a contractor of services as well as consultant.

Where prime responsibility for air sanitation is vested in the health department, the health officer must provide the vigorous leadership necessary to combat air pollution successfully and to foster the social and economic development of the community. The health agency must also provide in a competent and efficient manner the various services such as answering complaints, observing air pollution episodes, making engineering surveys of air pollution sources, testing stack discharges, sampling and analyzing the air over the community, reviewing plans, and issuing permits.

Also, the health department must assume responsibility for coordination of air pollution control efforts with other governmental operations, such as, city planning, zoning, urban development and redevelopment, and traffic. The health department cannot ignore air pollution nuisances and concentrate only on health hazards; it must provide a total community program to satisfy all needs.

In many instances, air pollution problems transcend the boundaries of a single political jurisdiction. This is an old problem for public health administrators. Cooperation is necessary to develop the appropriate regional administrative machinery to handle such problems effectively.

In a few areas, special districts or authorities have been established. However, such single purpose districts help to confound the problem of government in metropolitan areas. Also, many political scientists object to the removal of control of the government by the people that is inherent in many such systems. It would seem that the experience of public health administrators could be directed to this problem to evolve a more satisfactory solution.

Summary

There appear to be a few basic points that public health administrators and others may consider with respect to the establishment and organization of air pollution control activities:

1. Local conditions and emphasis desired will help determine the best organizational setting for any air pollution control activities.

2. Observed and suggested health effects of air pollution will cause increased investigation by health authorities.

3. Because of its natural interest in the total health of the community, the health agency must be concerned with air pollution.

4. The health department may be involved in air pollution control in 1 of 2 ways: either as a consultant and adviser or as a primary administrator.

5. The health department's concern with the total environment, of which air is a vital component, provides many advantages favoring the health department as the primary administrator of the air pollution control program.

6. The health officer should avoid commitments to air pollution control when he is unwilling or unable to provide the leadership, budget, and emphasis required by local conditions.

7. Where public health administrators are interested in air pollution control, the health department has much to offer in the way of experienced community leadership, efficiency through coordination with other activities, adaptable personnel with parallel training and experience, and laboratory facilities. In such a setting, a program may be developed that will protect the public health and foster the economic and social development of the community.

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Report of National Conference on Nursing Homes and Homes for the Aged, 1958. *PHS Publication No. 625; 85 pages; 55 cents.*

Complete proceedings of the first National Conference on Nursing Homes and Homes for the Aged held in Washington in February 1958 are presented. Principal addresses, background information, 103 recommendations adopted by the conference, and a synthesis of the discussions which led to each recommendation are included.

Recommendations and related discussions are grouped according to the eight sections in which they were evolved: role of nursing homes and homes for the aged (general policy questions); medical, nursing, and other selected professional services; nutrition and food service; social and related services; environmental health and safety; regulatory agency problems; financing of facilities and services (including design, construction, and equipment facilities); and administration.

Milestones in Venereal Disease Control. Highlights of a half-century. *PHS Publication No. 515; revised 1958; 12 pages; 10 cents.*

Brought up to date to include the newest techniques of serodiagnosis of syphilis, this easy-to-refer-to chronology is a modern history of venereal disease control. It will be useful to teachers, health and social workers, speakers, writers, and others needing ready reference to facts about the progress of venereal disease diagnosis and treatment.

Sources of Morbidity Data, Listing Number 6, 1958. *PHS Publication No. 628; 1958; 83 pages.*

Descriptions of 110 previously unreported projects in the files of the Clearinghouse on Current Morbidity Statistics Projects are grouped according to major type or types of disease, injury, or impairment with which they deal.

There are three indexes: the projects by type of data collection, the organizations chiefly responsible for the research, and the principal investigators. Also included is a section of supplementary notes representing a systematic followup on unfinished projects in the previous five listings.

The number of bound copies for distribution to other than actual and potential contributors is limited. Tearsheets for the projects are on file, however, for persons who inquire about studies of a particular type.

Immunization Information for International Travel. *PHS Publication No. 384; revised 1958; 71 pages; single copies, 30 cents, $22.50 per 100.*

Immunization requirements for persons entering the United States (including Americans returning from abroad), requirements and recommendations for immunization in 200 other countries, and a list of yellow fever vaccination centers are presented. Information on bringing pets into the United States is in a special section.

Designed primarily for travelers going abroad, health departments, and physicians, this booklet supersedes the 1956 edition and 1957 supplement.

Municipal Sewage Treatment Needs. *PHS Publication No. 619; 1958; by John R. Thoman and Kenneth H. Jenkins; 16 pages; 15 cents.*

Data from the 1957 Inventory of Municipal and Industrial Wastes Facilities show needs for sewage treatment plants. These needs are grouped into six categories including new and replacement plants and additions to existing facilities. Reported data and applicable percentages for the various categories are arranged by States, community population groups, and major drainage basins. Tables show needs for various degrees of treatment as well as for different types of plants within the primary and secondary groups.

This booklet is intended to be used in conjunction with Statistical Summary of Sewage Works in the United States, PHS Publication No. 609.

Source Materials on Water Pollution Control. *PHS Publication No. 243 (Public Health Bibliography Series No. 22); revised 1958; 24 pages.*

Current references, technical and nontechnical, are grouped under the headings: community action, financing and economic factors, laws and regulations, industrial wastes, domestic wastes, basic data and standards, research, biological aspects of water pollution, water supply, and films. In addition to about 100 PHS publications or reprints, references which may be consulted in libraries or purchased from the sources noted are listed.

Highlights of Progress in Research on Cancer. *PHS Publication No. 623; 1958; 51 pages; 25 cents.*

Research findings reported during 1957 by staff scientists and grantees of the National Cancer Institute, Public Health Service, are summarized to represent selected accomplishments in the study of cancer and to reflect current attitudes toward the more promising avenues of cancer research. The material ranges from basic laboratory studies and statistical analyses of the epidemiology of cancer to clinical research.

Summaries are organized under four broad headings: causation, characteristics, diagnosis, and treatment of cancer.

Health Statistics From the U. S. National Health Survey. Selected survey topics, United States, July 1957–June 1958. *PHS Publication No. 584–B5; 1958; 49 pages; 40 cents.*

Data collected from a continuous nationwide household-interview survey are the bases for this annual summary on disability, acute conditions, chronic conditions, persons injured, physician visits, and dental visits. Included are population estimates for use in rate computation in conjunction with the basic data.

This material is supported by 39 tables and 12 graphs. Explanatory text includes appendixes containing technical notes on methods and definitions of terms.

Air Pollution Measurements of the National Air Sampling Network. Analyses of suspended particulates, 1953–1957. *PHS Publication No. 637; 1958; 260 pages; $2.*

Air quality data from urban, suburban, and nonurban areas in the United States are reported. The text describes the analytical techniques applied to samples, and monthly and frequency distribution tables are presented for individual pollutants.

These data should be useful in determining correlations and trends in the nature, extent, causes, and effects of air pollution and in establishing the health significance of various pollutant levels.

Pneumonoconiosis in Diatomite Mining and Processing. *PHS Publication No. 601; 1958; 96 pages; 55 cents.*

Results of an epidemiological study of diatomaceous earth pneumonoconiosis in five diatomite plants in California, Nevada, and Oregon are described.

The report includes a review of the literature, a detailed description of diatoms and the diatomite-processing industry, discussion of the environmental and medical studies conducted, and specific recommendations for dust control, labeling, and a medical program.

The study was made by the Public Health Service in cooperation with the State health departments concerned.

A Manual for Metabolic Balance Studies. *PHS Publication No. 607; 1958; 31 pages; 20 cents.*

This manual presents basic information needed for conducting metabolic balance studies and describes methods used by the Arthritis and Metabolic Diseases Nursing Service of the Clinical Center, National Institutes of Health, Public Health Service.

In addition, there are chapters on the team concept for metabolic balance studies, the metabolic research diet, and orienting the patient.

Liberally illustrated, the manual is designed to aid researchers in nutrition, mineral and electrolyte metabolism, and cancer.

Homemaker Service. *Children's Bureau Folder No. 46; 1958; 36 pages; 15 cents.*

Plausible examples of family crises depict the philosophy and operation of the homemaker service. This booklet tells who may need the service, under what circumstances it may be used, and how it may be financed. Establishing a homemaker service and its value to the community are also discussed.

The Water Pollution Control Program of the U. S. Public Health Service, 1957–1958. *PHS Publication No. 631; 1958; 26 pages; 25 cents.*

After recounting the changing water pollution problems, this brochure describes the program for their control.

The evolution of the program is outlined in sections on legislative history and congressional policy. Construction of sewage treatment plants, interstate enforcement activities, research, and basic data analysis are reported in nontechnical language.

Directed to the individual citizen, the last section summarizes the benefits, goals, and costs of the program.

Child-Caring Institutions. Their new role in community development of services. *Children's Bureau Publication No. 368; 1958; by Martin Gula; 27 pages; 15 cents.*

New patterns in community services and new demands on child-care institutions are discussed in relation to the dynamics of the individual community and changing conditions during the past 50 years.

Against this background, three levels of quality of establishments for the care of children are evolved, and 20 ways to measure the effectiveness of these institutions are listed.

The booklet stresses the importance of close working relationships between organizations for children and the community. It should be useful to board and professional staff members of social agencies, community planning groups, legislators, and judges.

Where to Write for Birth and Death Records. *PHS Publication No. 630A; 1958; 10 pages; 15 cents.*

Where to Write for Marriage Records. *PHS Publication No. 630B; 1958; 8 pages; 5 cents.*

Where to Write for Divorce Records. *PHS Publication No. 630C; 1958; 8 pages; 10 cents.*

Information for getting records on births and deaths, marriages, and divorces from States, Territories, and other American governmental agencies is supplied. In addition, the first-named publication tells how to obtain records pertaining to births and deaths occurring in selected foreign countries.

Multiple Sclerosis. Hope through research. *PHS Publication No. 621 (Health Information Series No. 92); 1958; leaflet; single copies, 5 cents, $3 per 100.* Describes symptoms of multiple sclerosis. Reviews theories on causes. Discusses research advances in diagnosis and possible treatment.

This section carries announcements of new publications prepared by the Public Health Service and of selected publications prepared with Federal support.

Unless otherwise indicated, publications for which prices are quoted are for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Orders should be accompanied by cash, check, or money order and should fully identify the publication. Public Health Service publications which do not carry price quotations, as well as single sample copies of those for which prices are shown, can be obtained without charge from the Public Inquiries Branch, Office of Information, Public Health Service, Washington 25, D. C.

The Public Health Service does not supply publications other than its own.

ROCKY MOUNTAIN SPOTTED FEVER: VACCINATION OF MONKEYS AND MAN

By R. R. SPENCER, Surgeon, and R. R. PARKER, Special Expert, United States Public Health Service

In a previous publication [1] we have shown that guinea pigs may be successfully vaccinated against Rocky Mountain spotted fever by injections of phenolized emulsions of tick virus. Data are now submitted which (1) prove that this vaccine will also protect monkeys and (2) suggest that it will confer immunity upon man.

PREPARATION OF THE VACCINE

The production of a potent vaccine from tick emulsions is dependent upon a high concentration of virus in the ticks from which it is prepared. By the injection of decreasing amounts of emulsions of infected tick viscera into guinea pigs, the minimal infectious dose of any given emulsion may be approximately determined. After many such titrations, employing fed and unfed infected ticks (*D. andersoni*) at all stages of the life cycle, it has been found that the highest concentrations of spotted fever virus occur two to four days after the beginning of the adult feeding.[2]

Such ticks, usually in lots of 100, are permitted to feed three days on guinea pigs, then at once eviscerated one by one and ground in a mortar for 10 or 15 minutes with sterile sand and a few cubic centimeters of salt solution. By this procedure the internal organs

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[1] Spencer, R. R., and Parker, R. R.: Rocky Mountain Spotted Fever: Experimental Studies on Tick Virus. Pub. Health Rept., Nov. 28, 1924. (Reprint No. 976.)

[2] *Rearing of infected ticks for the preparation of the vaccine.*—The rearing of adult ticks from which the ... ged and tedious process. (Potent virus can not be obtained from the tick in the ... the infection. Virus ingested by larvae does not increase appreciably ... age, or nymphs, that any increase in amount or virulence ... increase is often greater than in the nymphs. ... then reared to adults; for it is in ... necessary to begin opera- ... are selected ... tion

October 9, 1925, pp. 2159–2167

Dr. R. R. Spencer and Dr. R. R. Parker found that a vaccine produced from tick emulsion immunized monkeys and perhaps man against Rocky Mountain spotted fever. In earlier studies, they demonstrated that this vaccine immunized guinea pigs (Public Health Reports 38: 333–339, Feb. 23, 1923, and 39: 3027–3040, Nov. 28, 1924).